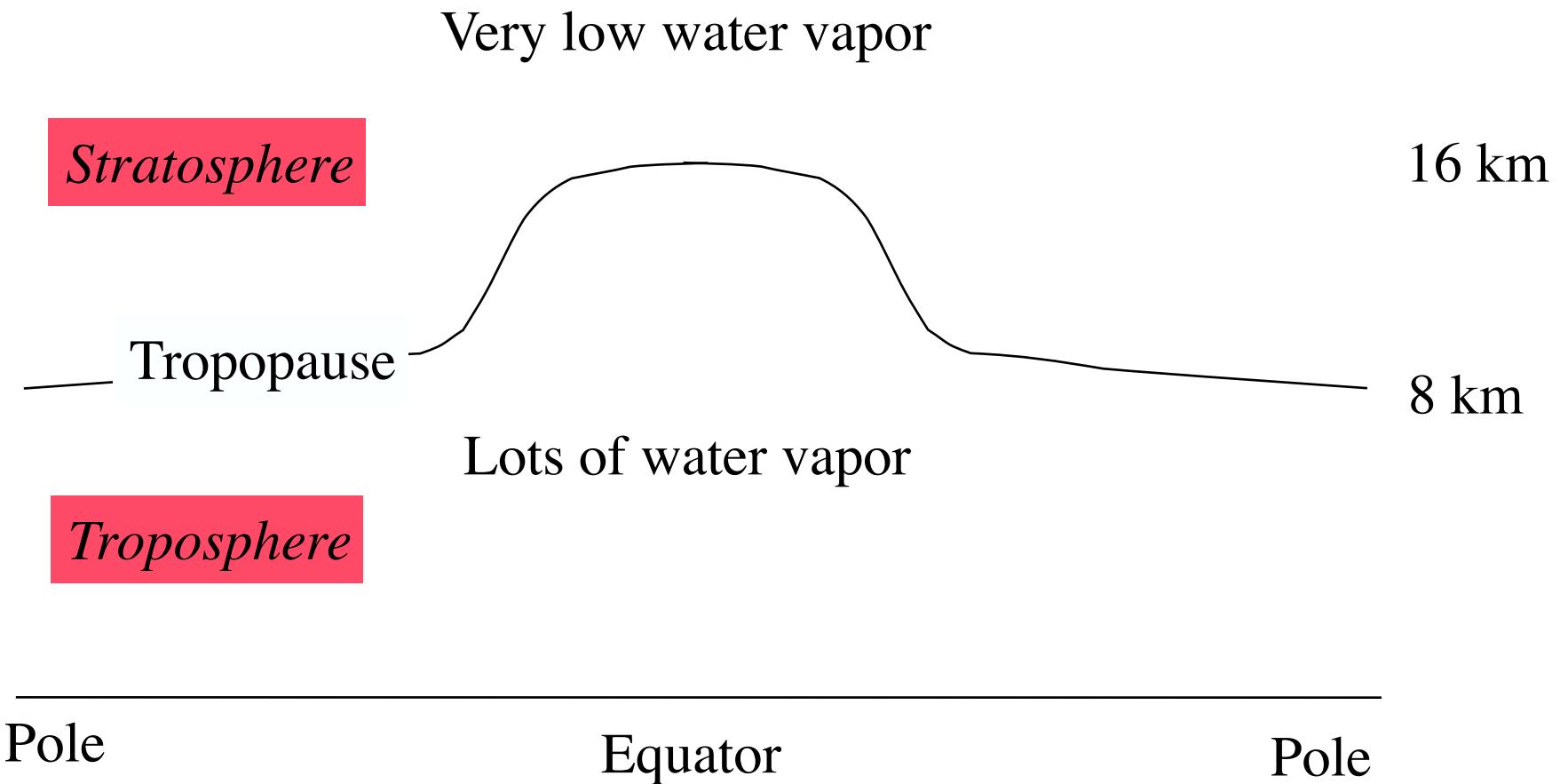


Observations of hydration and dehydration in the TTL

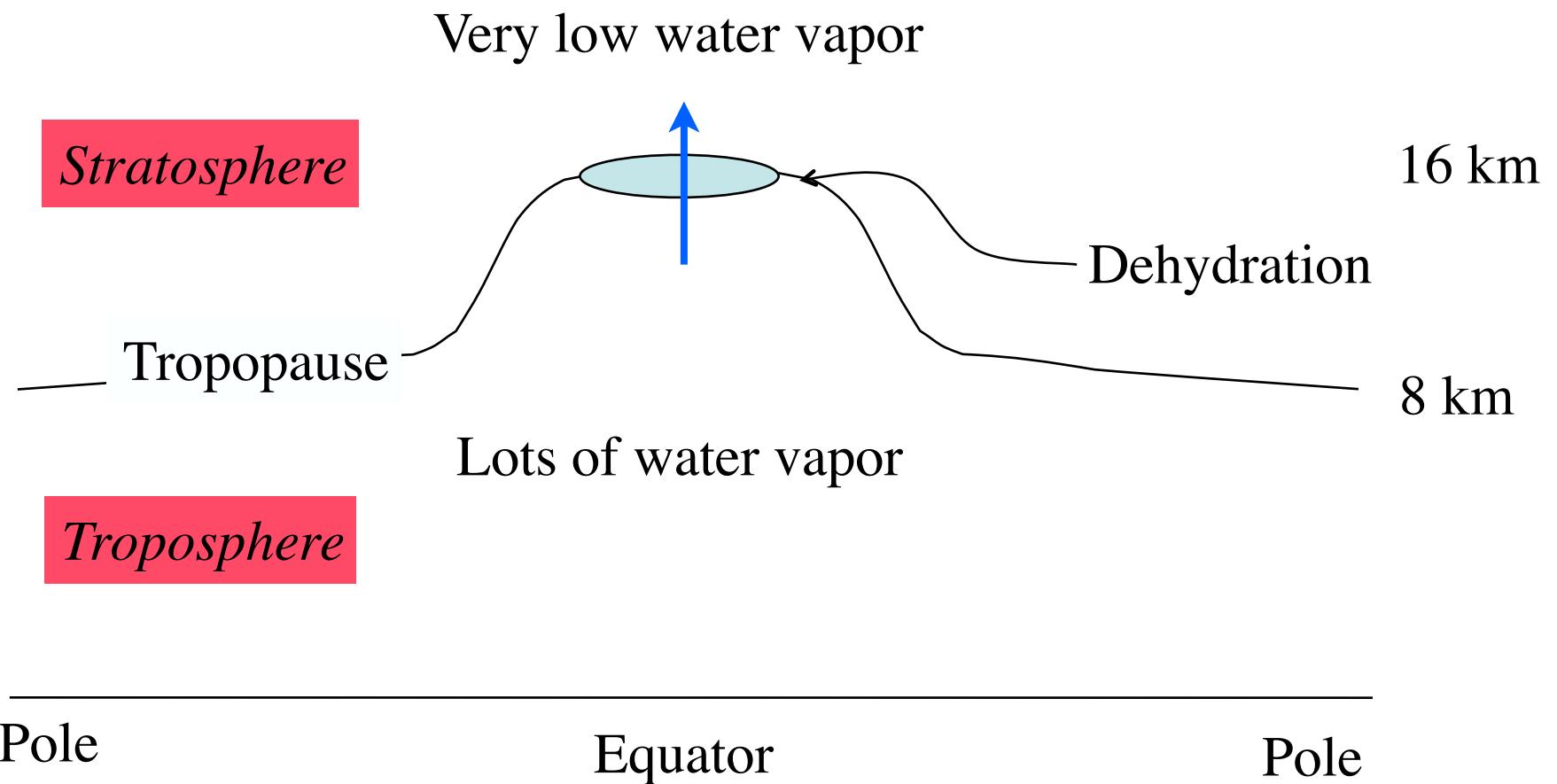
A. E. Dessler and S. Wong
Department of Atmospheric Sciences
Texas A&M University

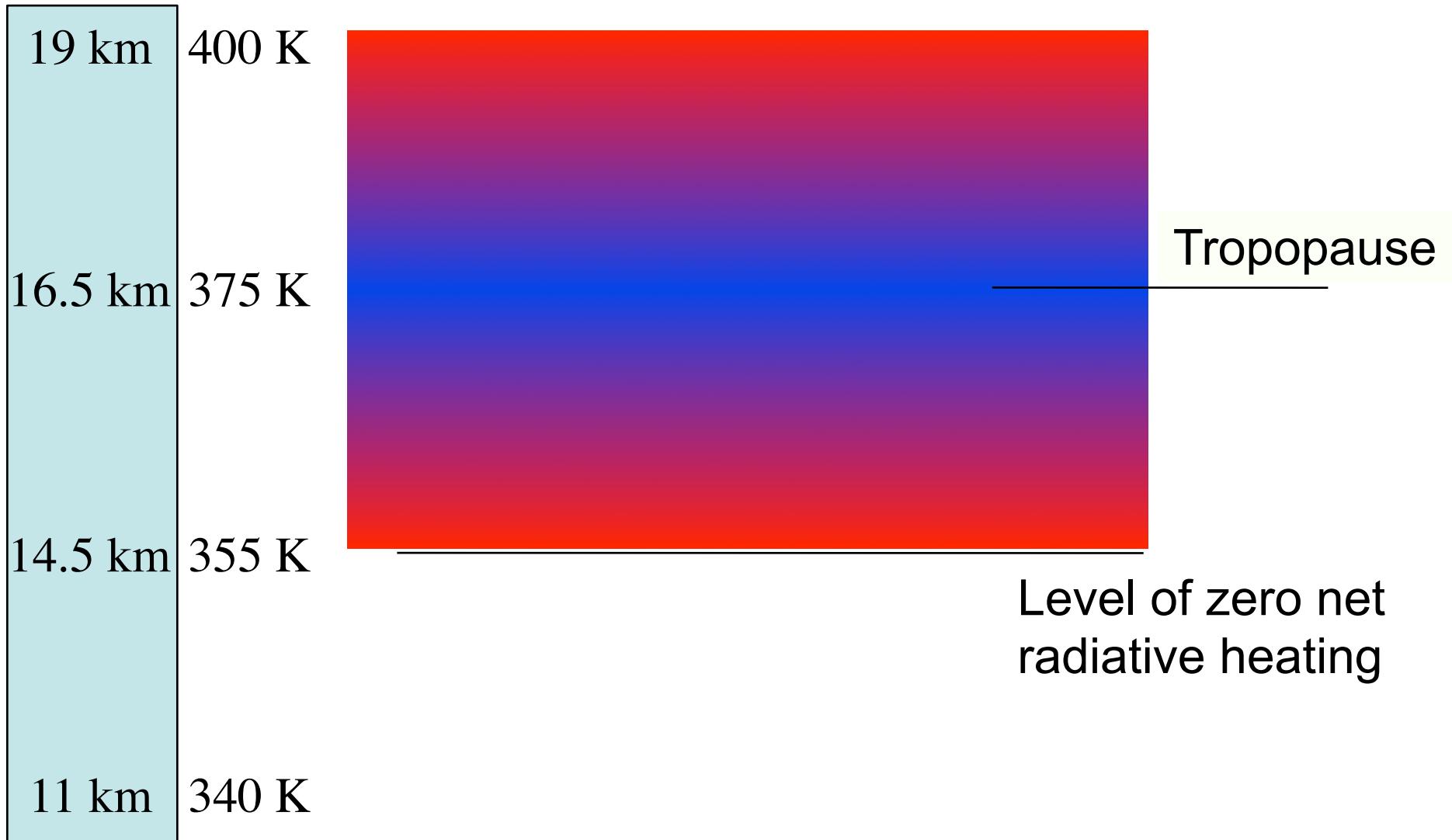


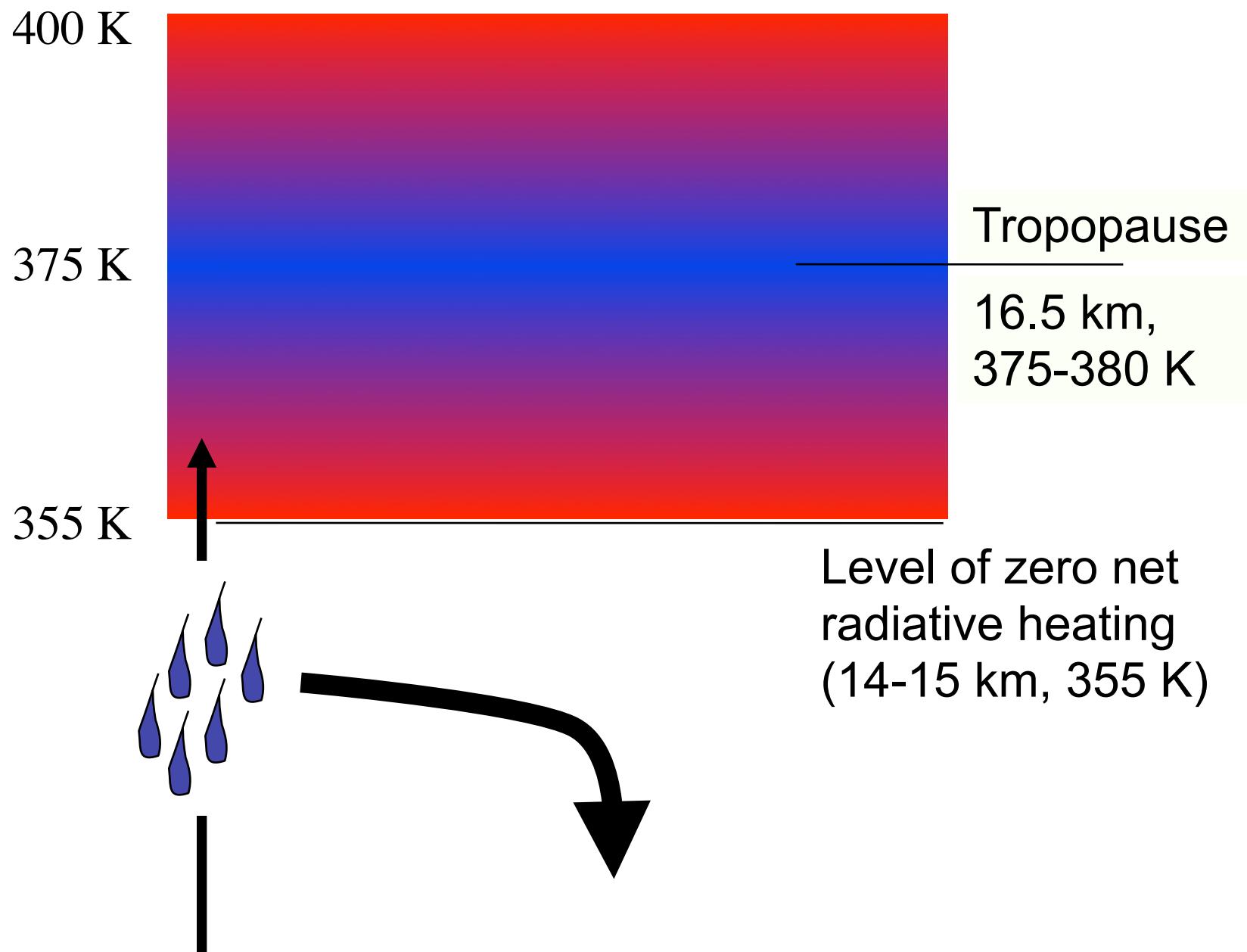
Brewer, Evidence for a world circulation provided by the measurements of helium and water vapour distribution in the stratosphere, Q. J. R. Meteorol. Soc., 1949.



Brewer, Evidence for a world circulation provided by the measurements of helium and water vapour distribution in the stratosphere, Q. J. R. Meteorol. Soc., 1949.



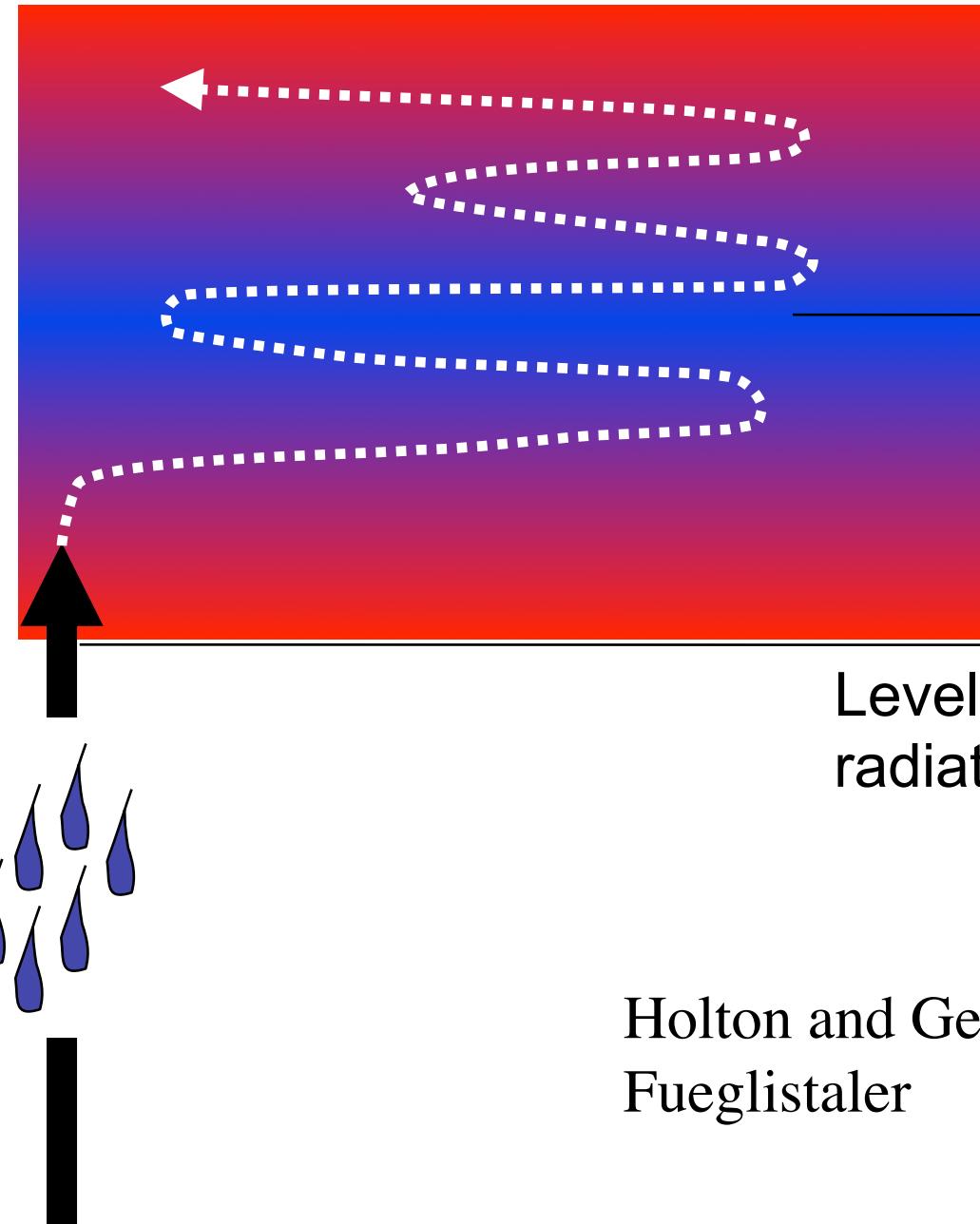




400 K

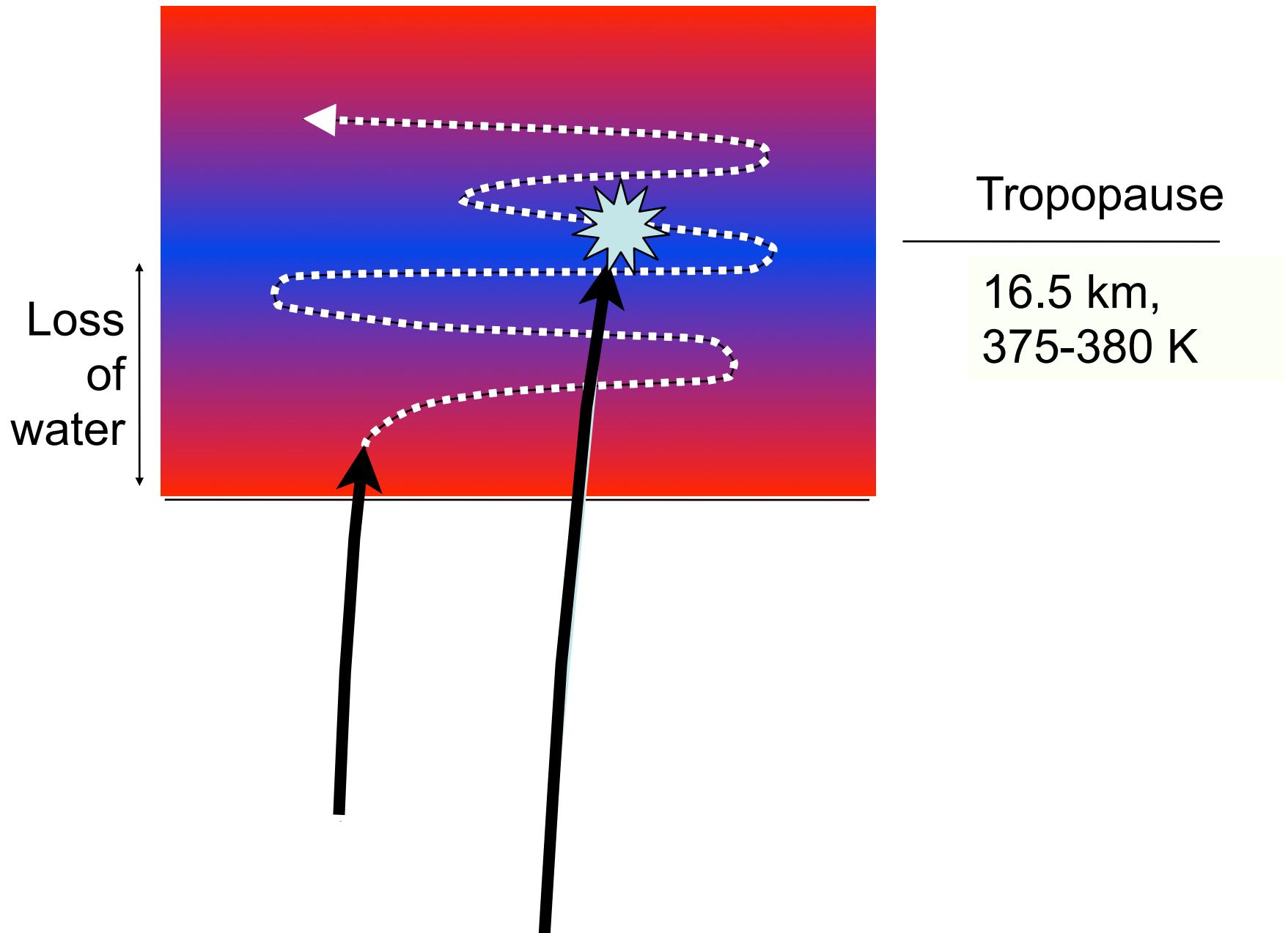
375 K

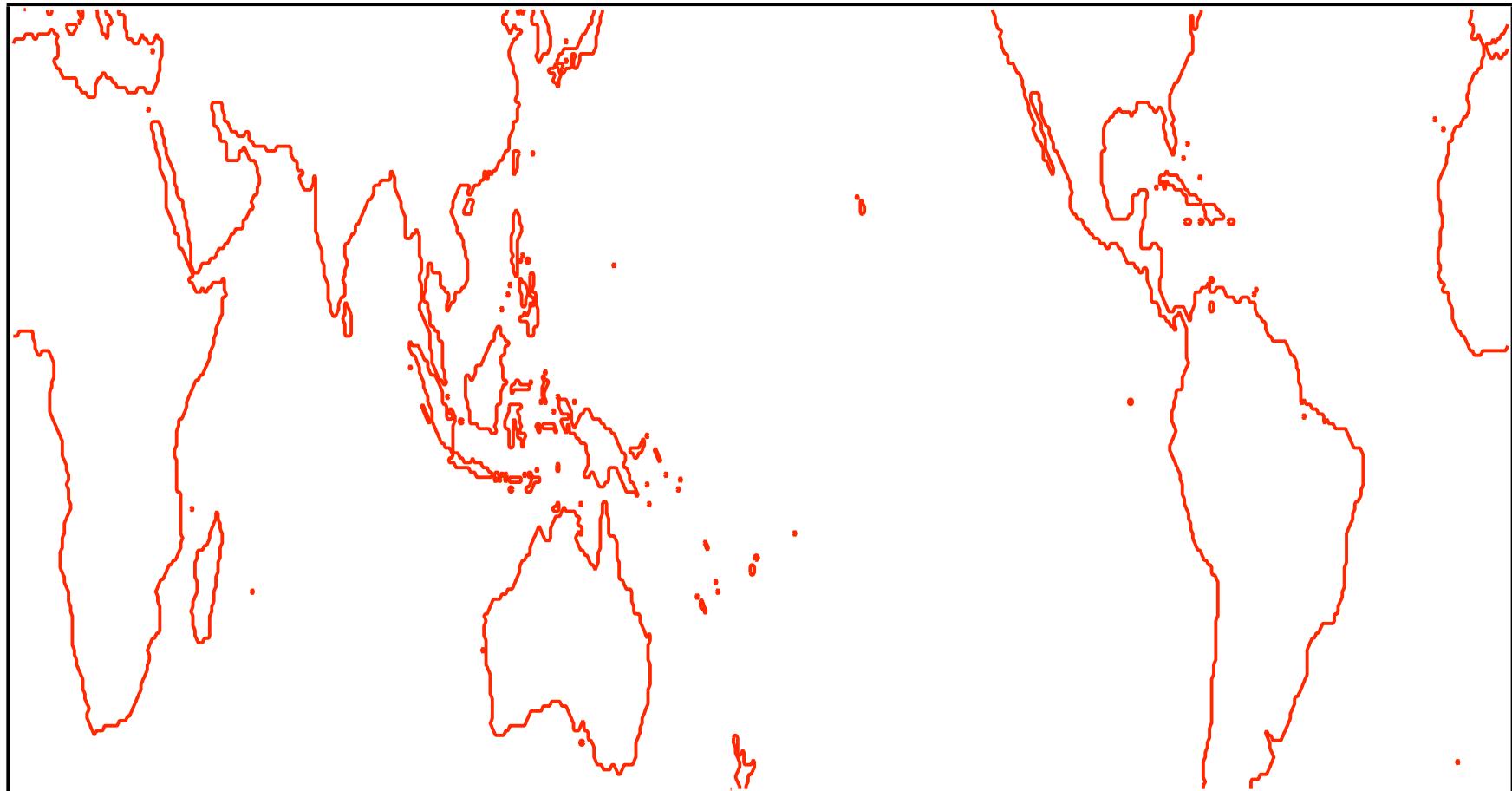
355 K

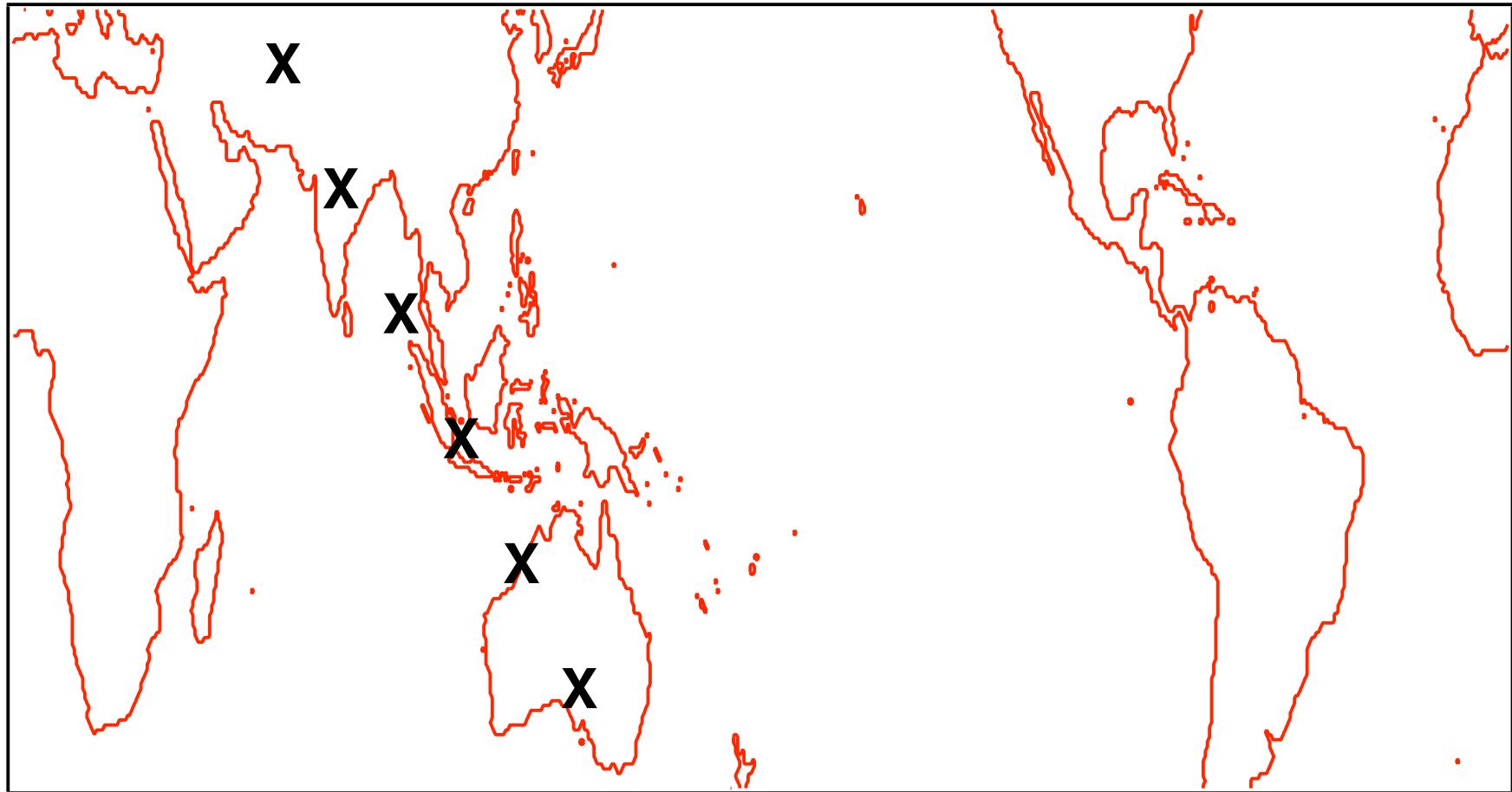


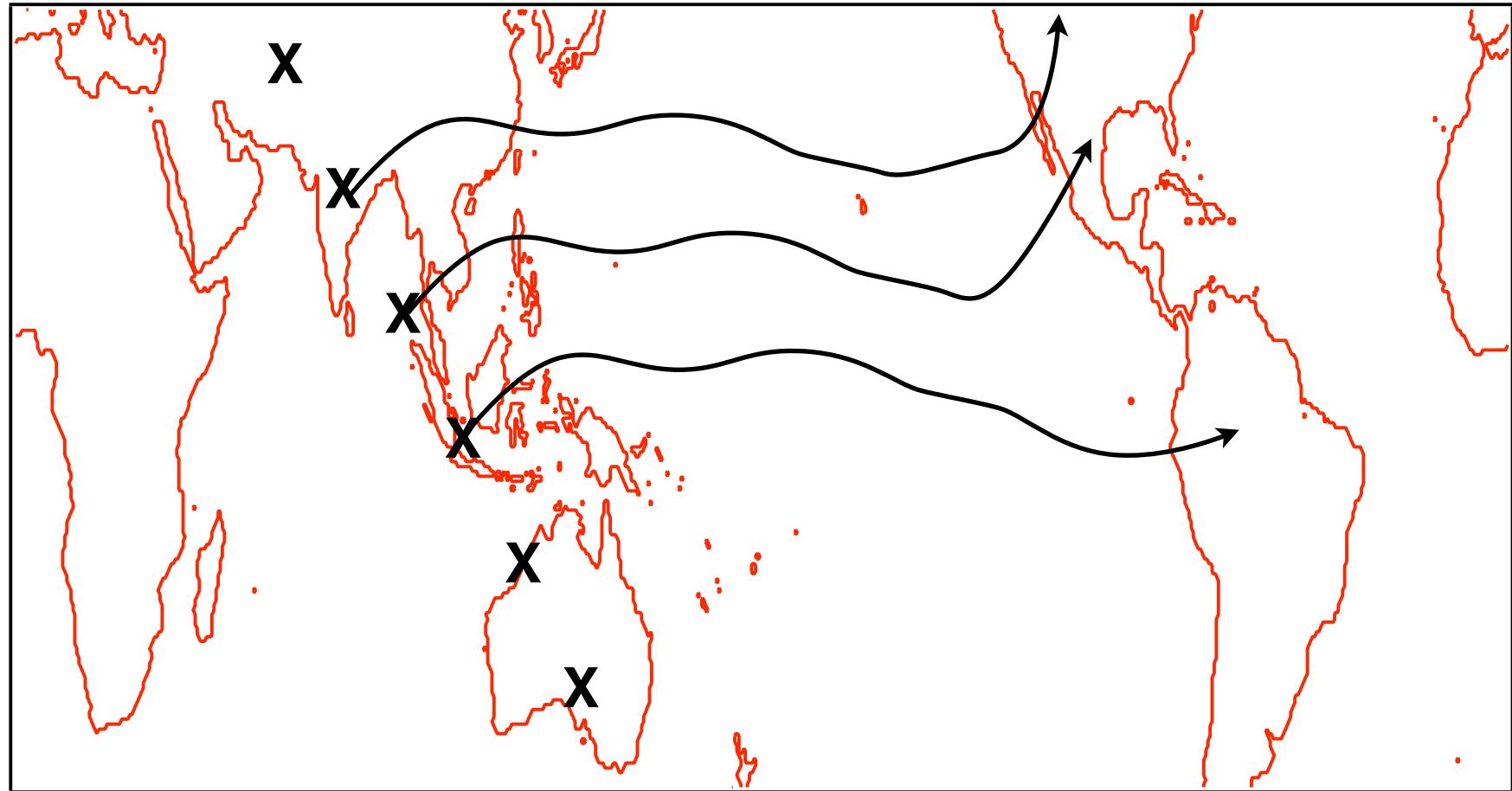
Level of zero net
radiative heating

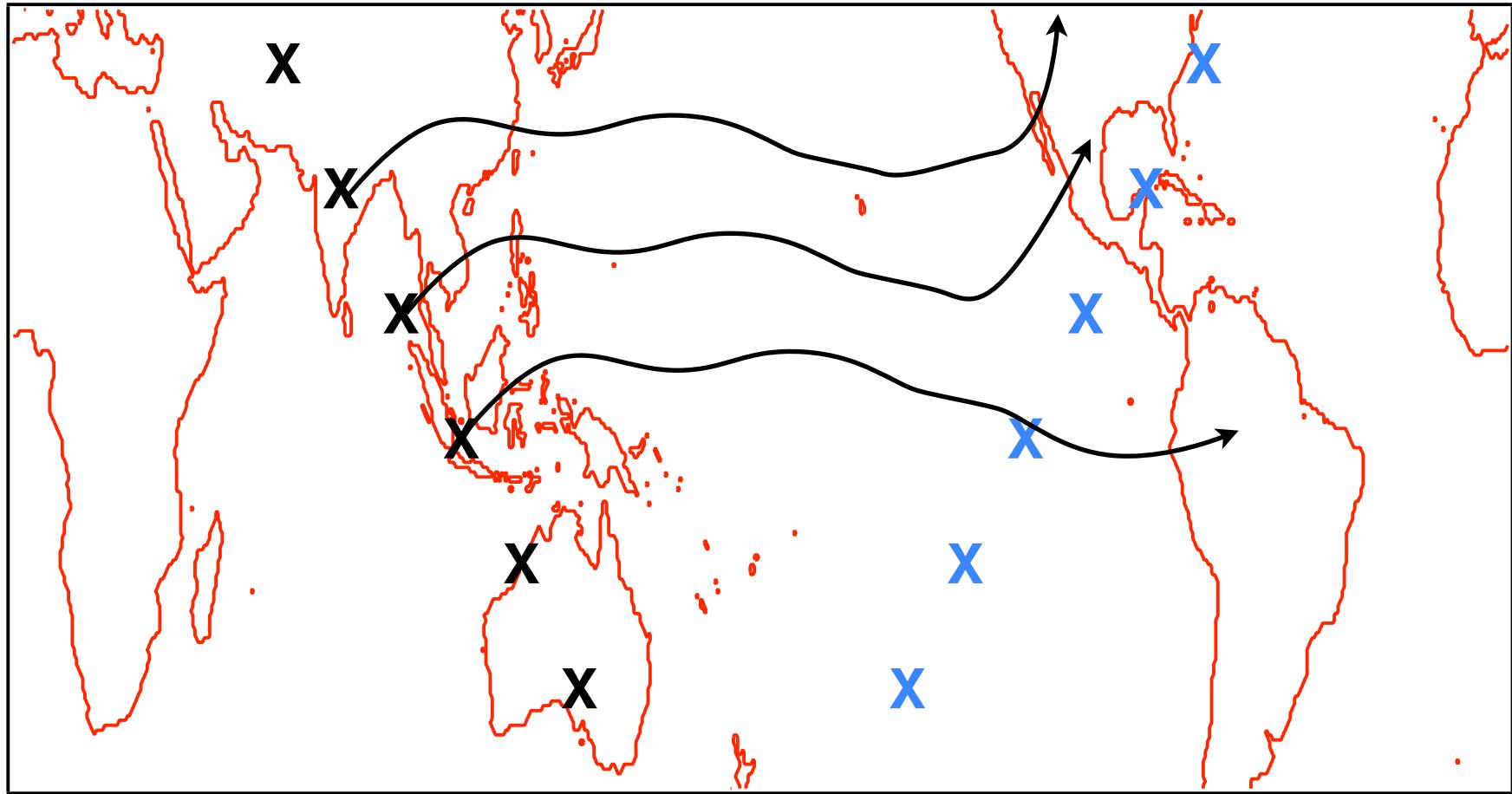
Holton and Gettelman,
Fueglistaler

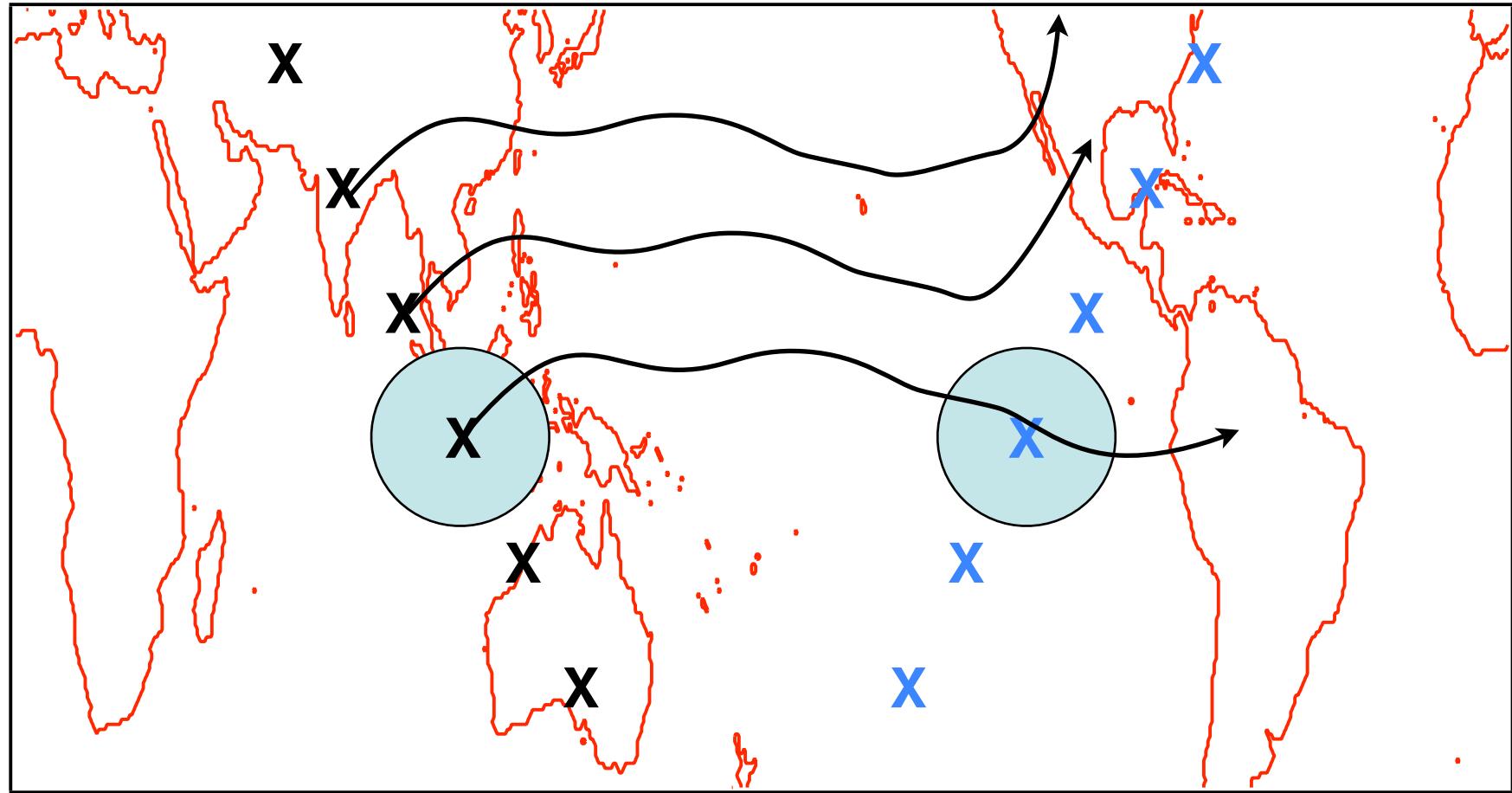






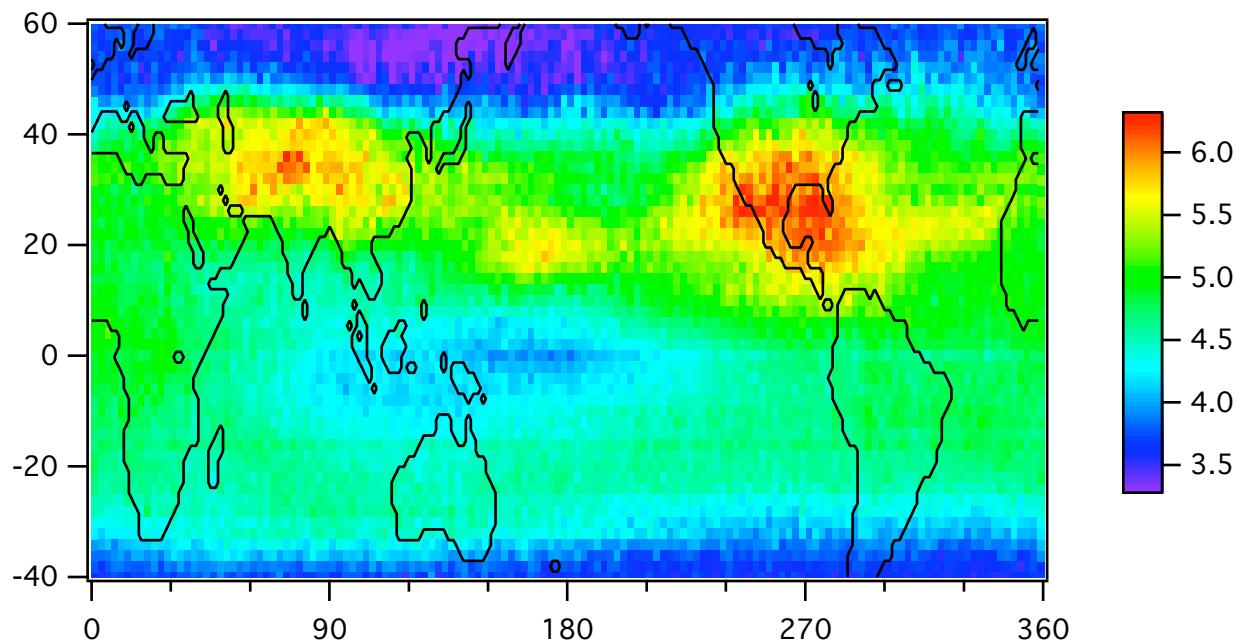






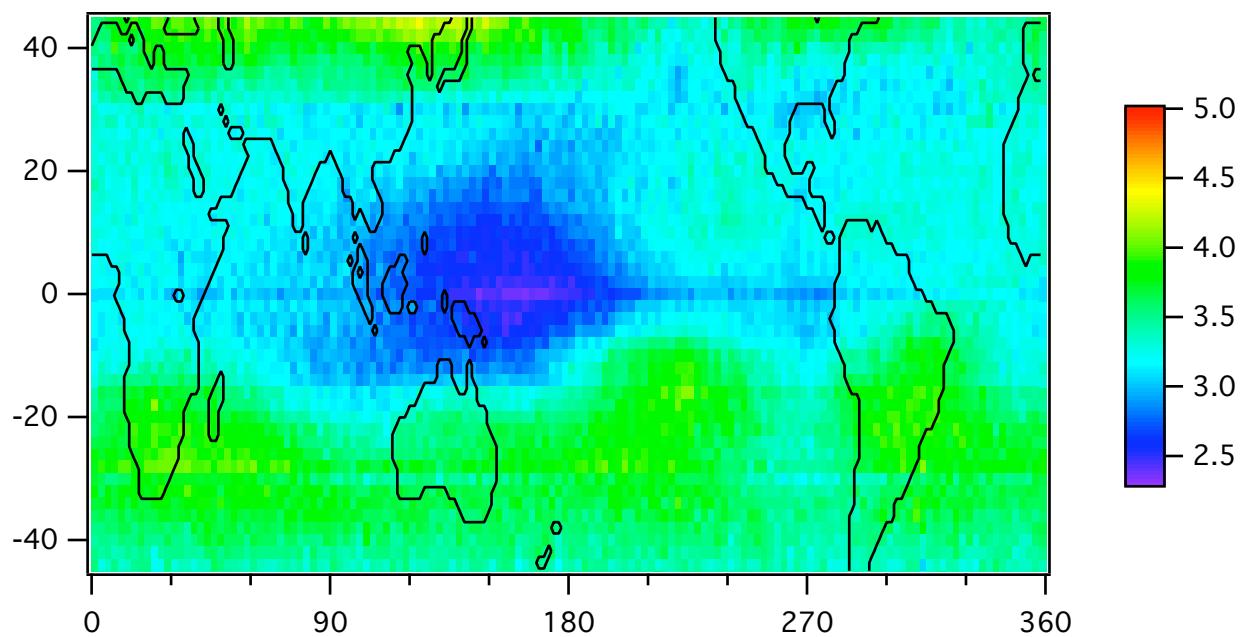
The details

- MLS v2.2 measurements of H₂O
- isentropic trajectories at 380 K (Schoeberl ftraj model)
- GEOS 5 winds
- run trajectory forward for 3 days
- look for MLS measurements within 300 km and 2.4 hours of the trajectory
- measurements must be more than 24 hours apart
- summer: JJA, winter: JFM; both cover 2005-2008
- ~1 million pairs for each season
- Similar to “trajectory mapping” of Morris et al. and “MATCH” technique of Rex et al.; denitrification study of Dessler et al. 1999
- OLR is from the NCEP
- RH is calculated using MLS H₂O and GEOS T



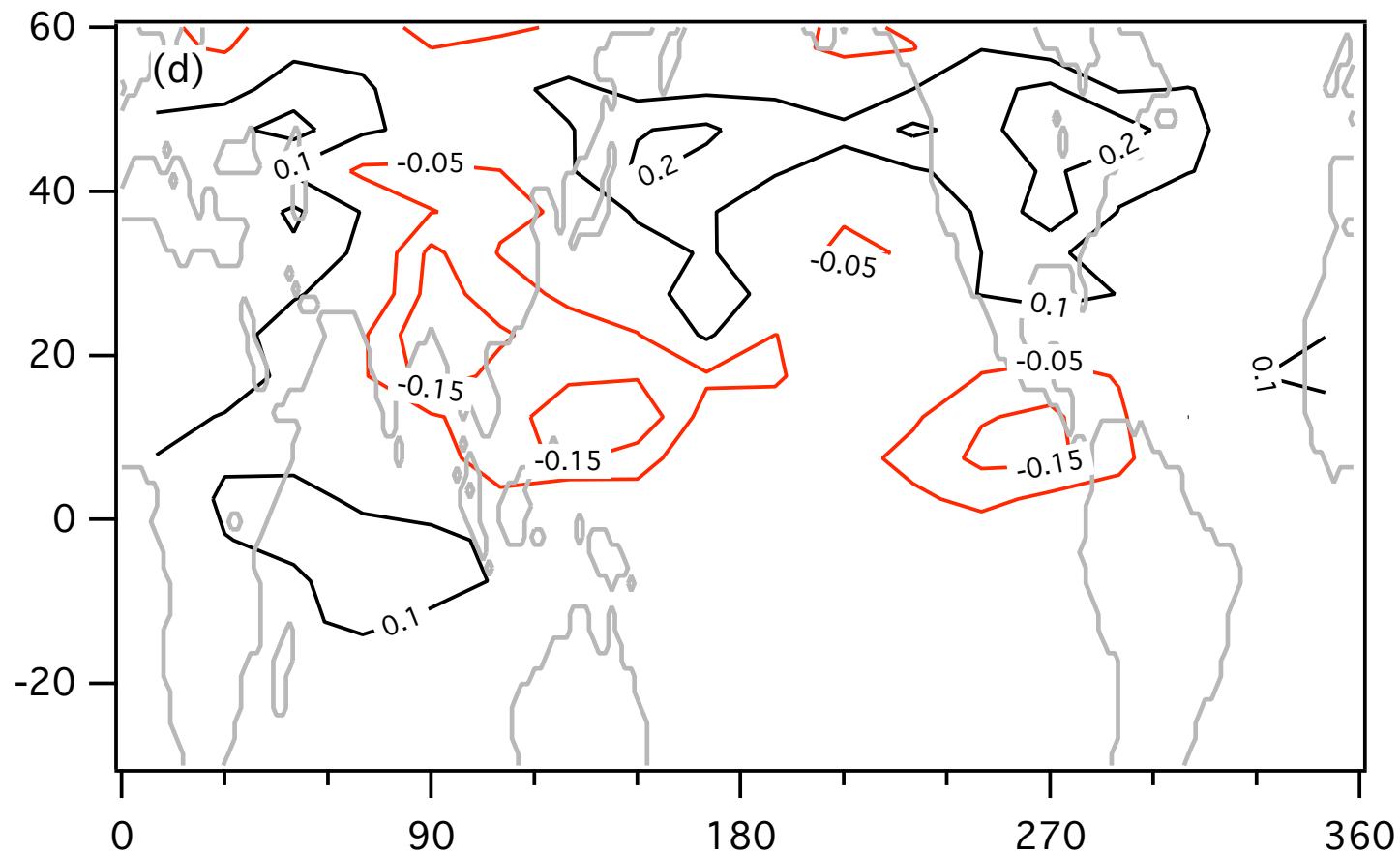
MLS v2.2
380 K

JJA



JFM

JJA



dehydration
hydration

$$\frac{dH_2O}{dt} = \dot{\theta} \frac{\partial H_2O}{\partial \theta} + \text{convection - dehydration} \pm \text{mixing}$$

$$\frac{dH_2O}{dt} = \dot{\theta} \frac{\partial H_2O}{\partial \theta} + \text{convection - dehydration} \pm \text{mixing}$$

upward motion
brings up high H₂O

$$\frac{dH_2O}{dt} = \dot{\theta} \frac{\partial H_2O}{\partial \theta} + \text{convection} - \text{dehydration} \pm \text{mixing}$$

upward motion
brings up high H₂O

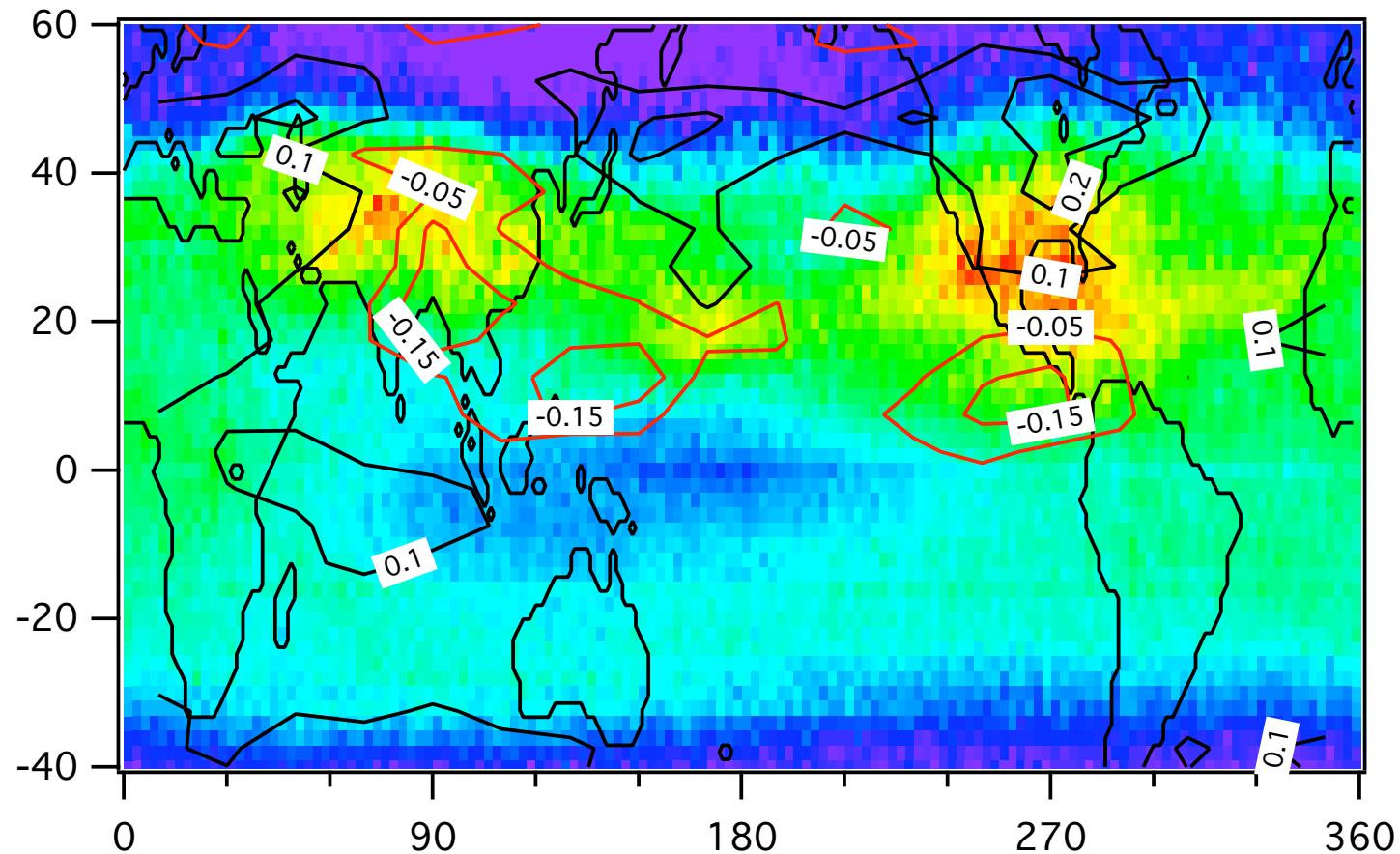
dehydration
reduces H₂O

$$\frac{dH_2O}{dt} = \dot{\theta} \frac{\partial H_2O}{\partial \theta} + \text{convection} - \text{dehydration} \pm \text{mixing}$$

upward motion
brings up high H₂O

dehydration
reduces H₂O

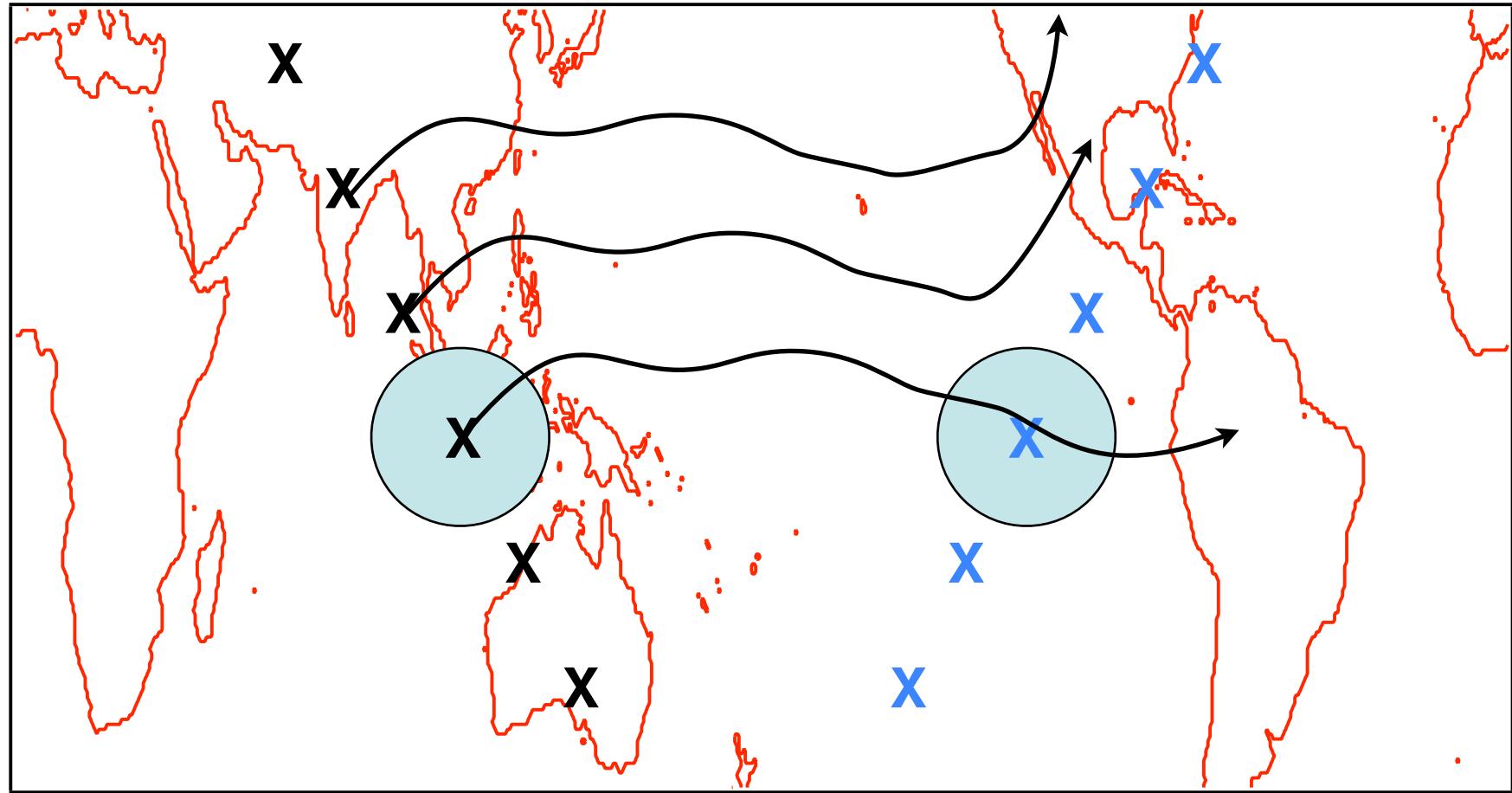
?

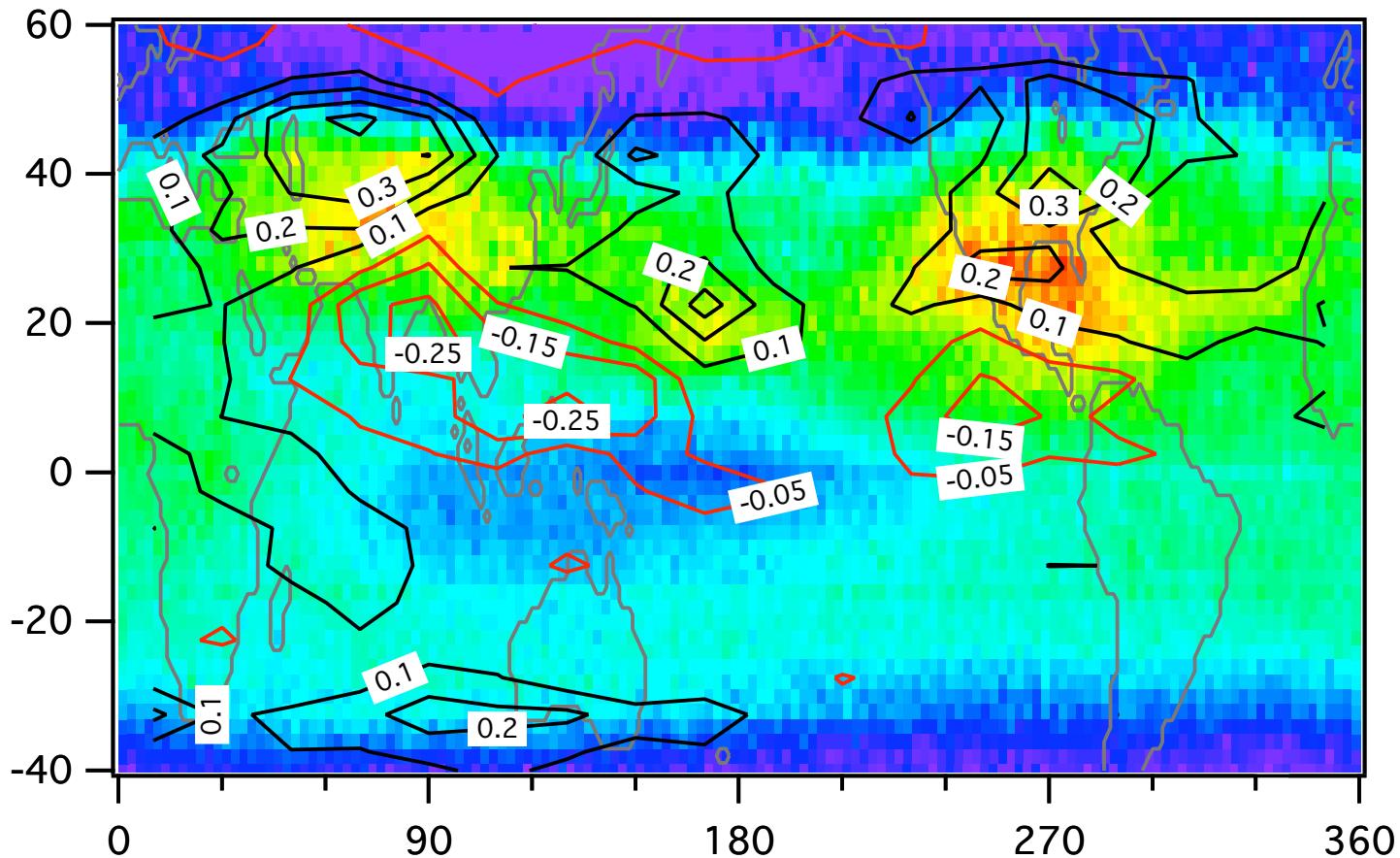


JJA

Water vapor (ppmv)

dehydration
hydration

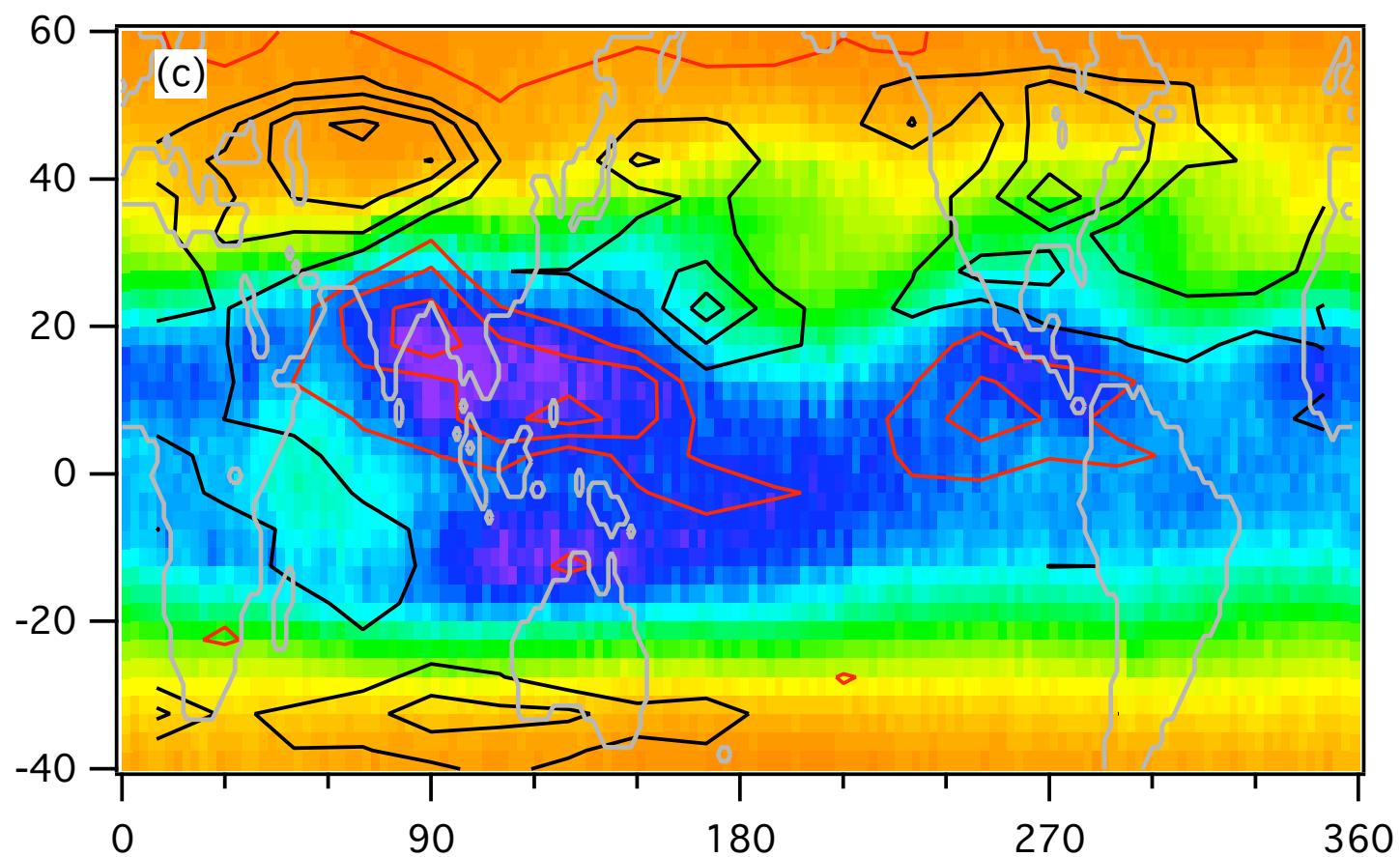




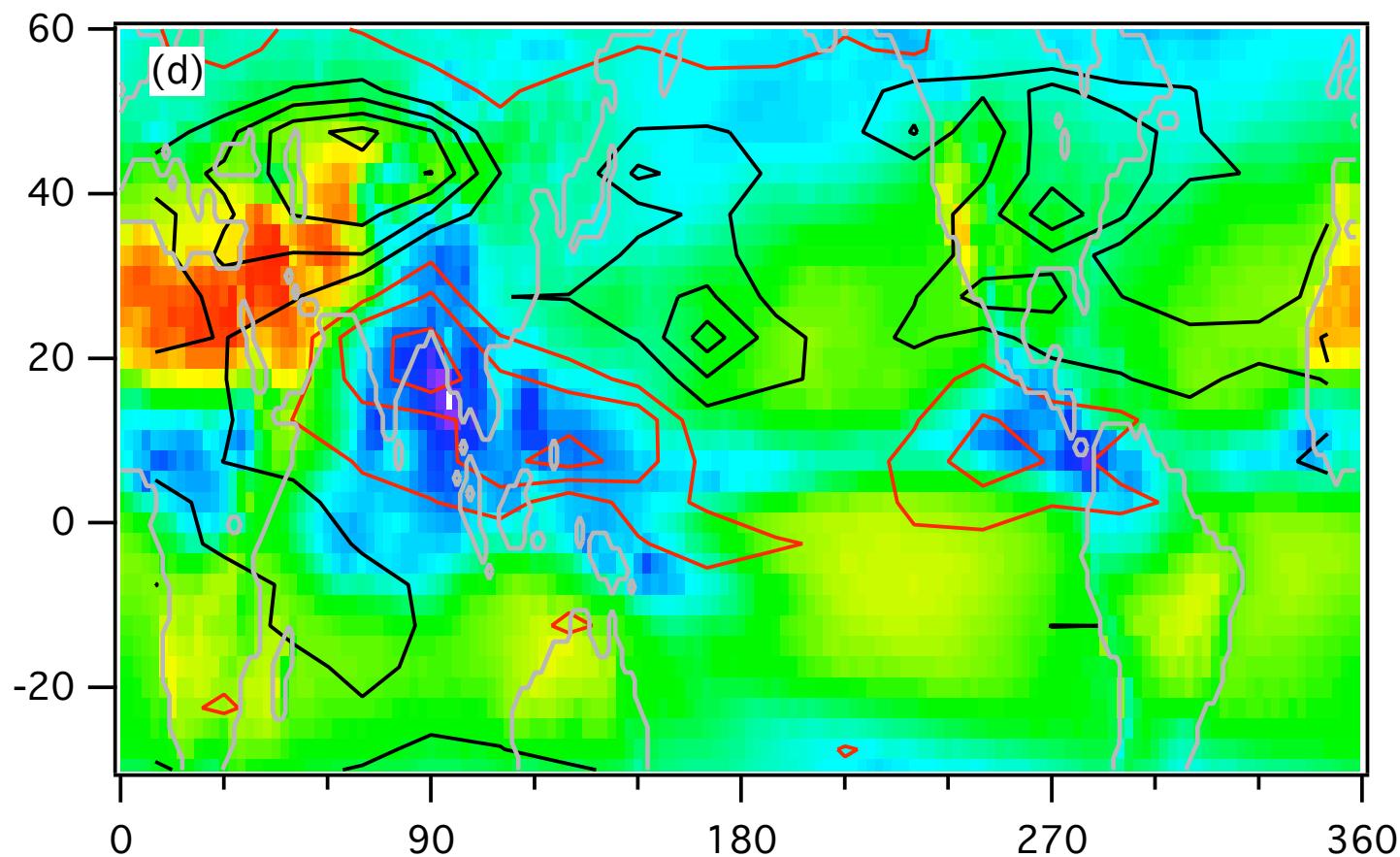
Water vapor (ppmv)

dehydration
hydration

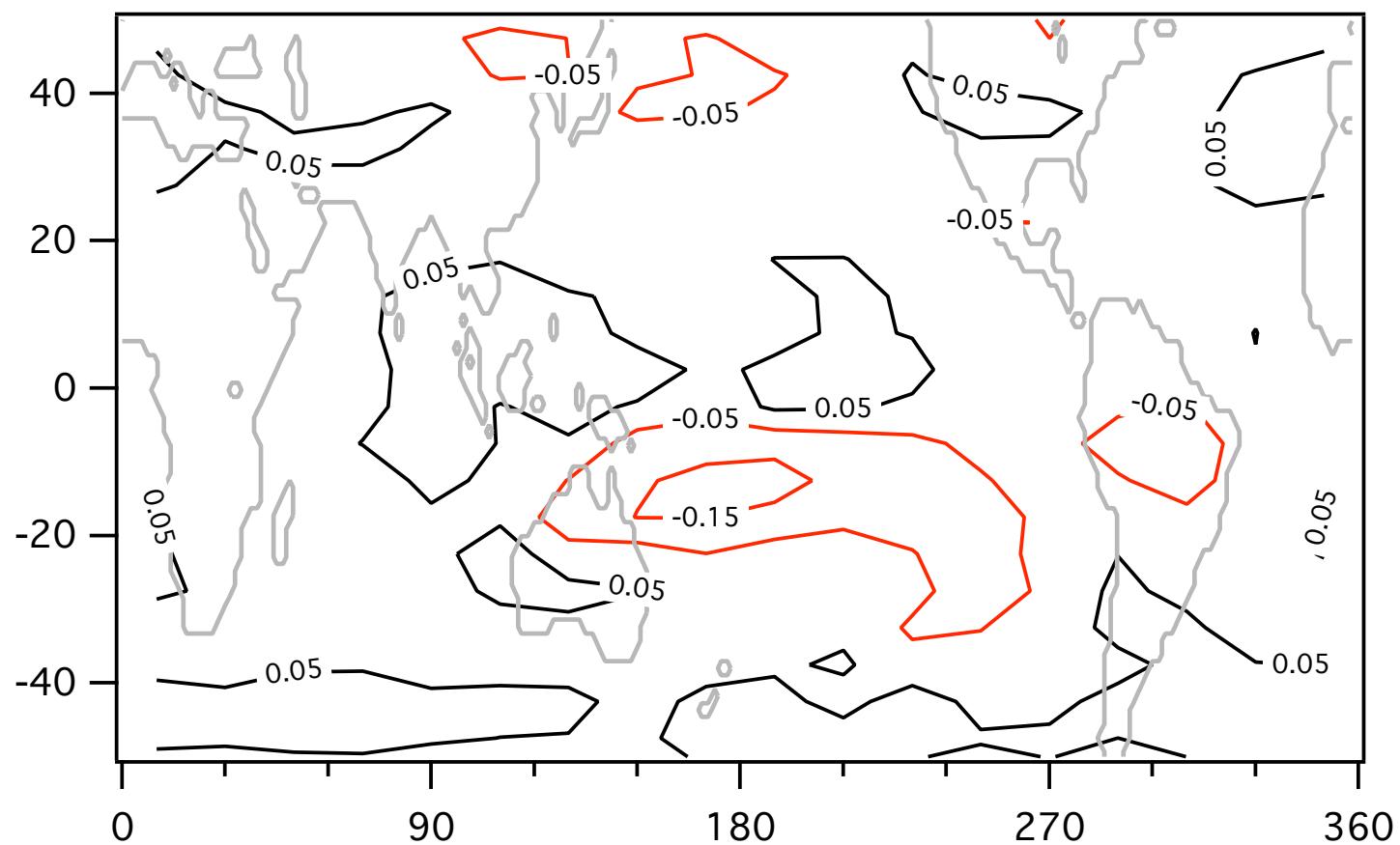
JJA



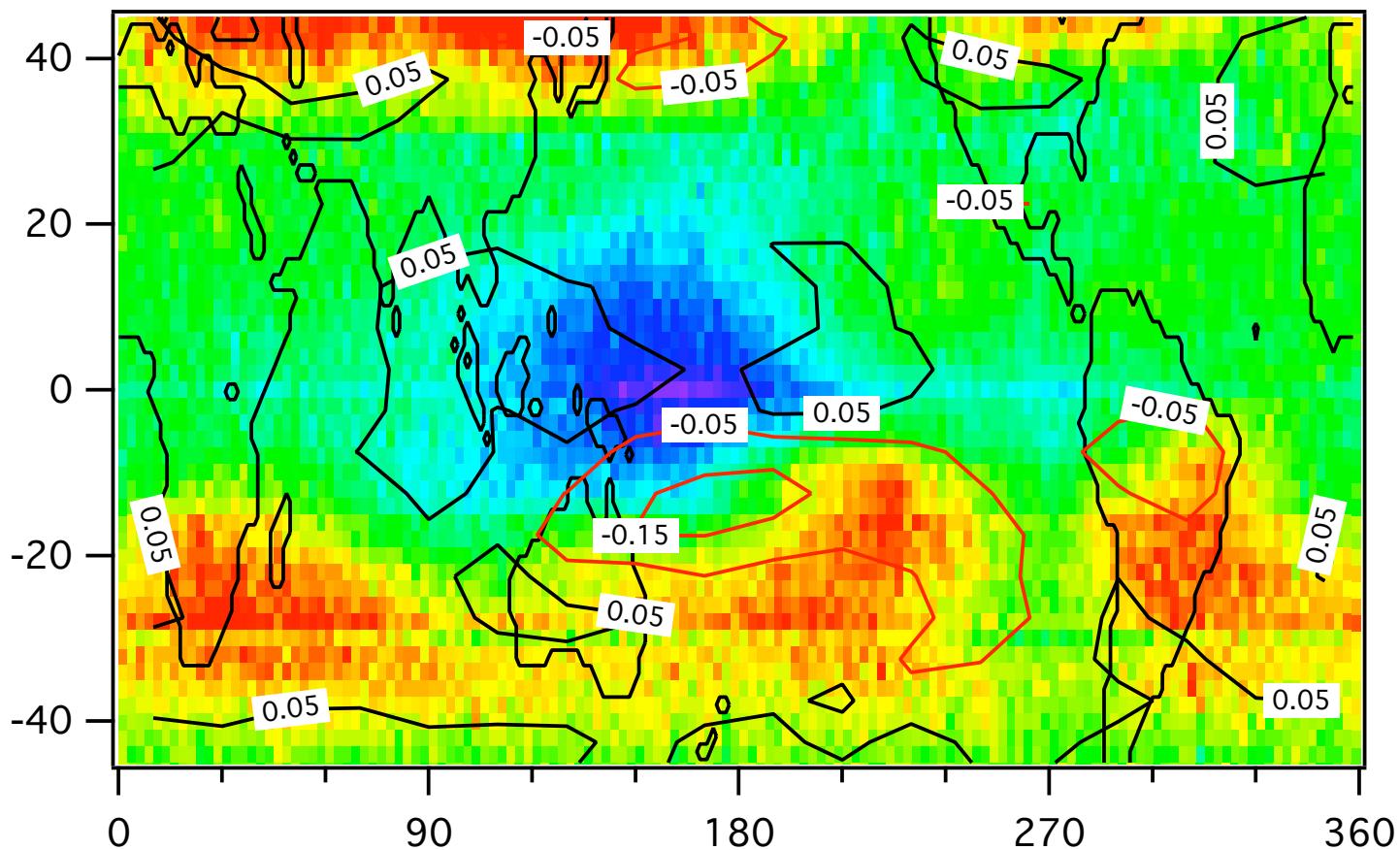
JJA



JFM



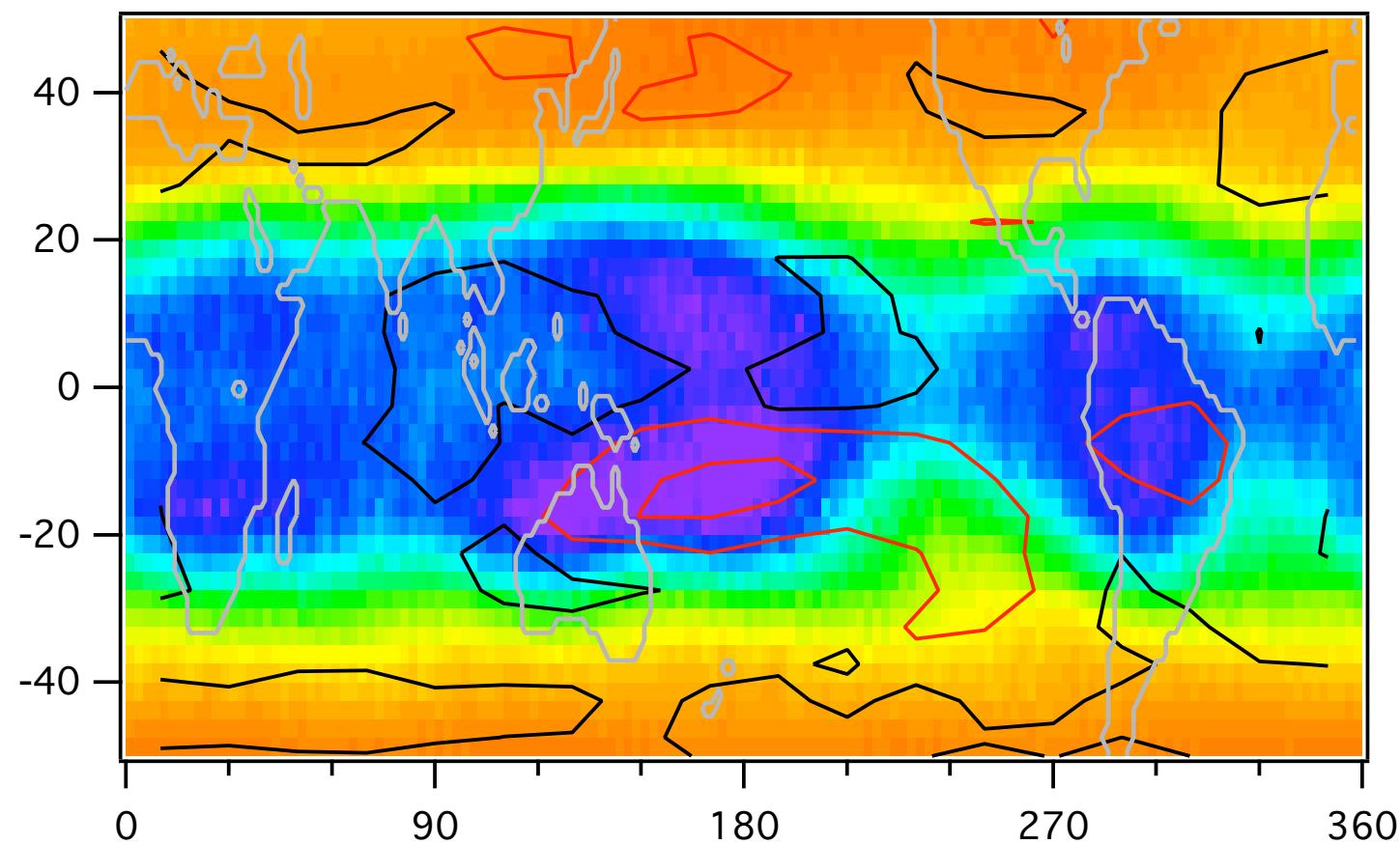
dehydration
hydration



Water vapor (ppmv)

dehydration
hydration

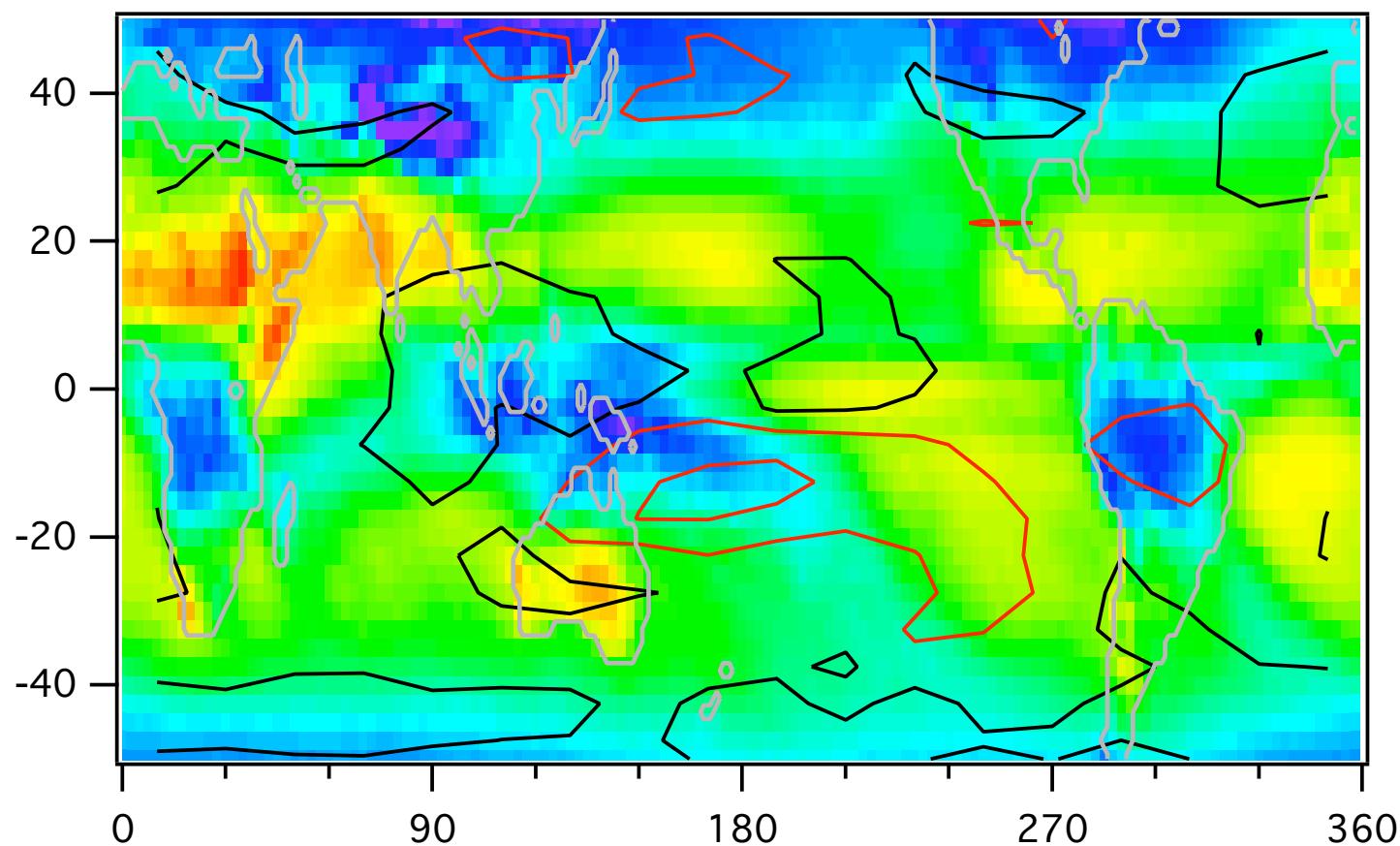
JFM



Relative humidity

— dehydration
— hydration

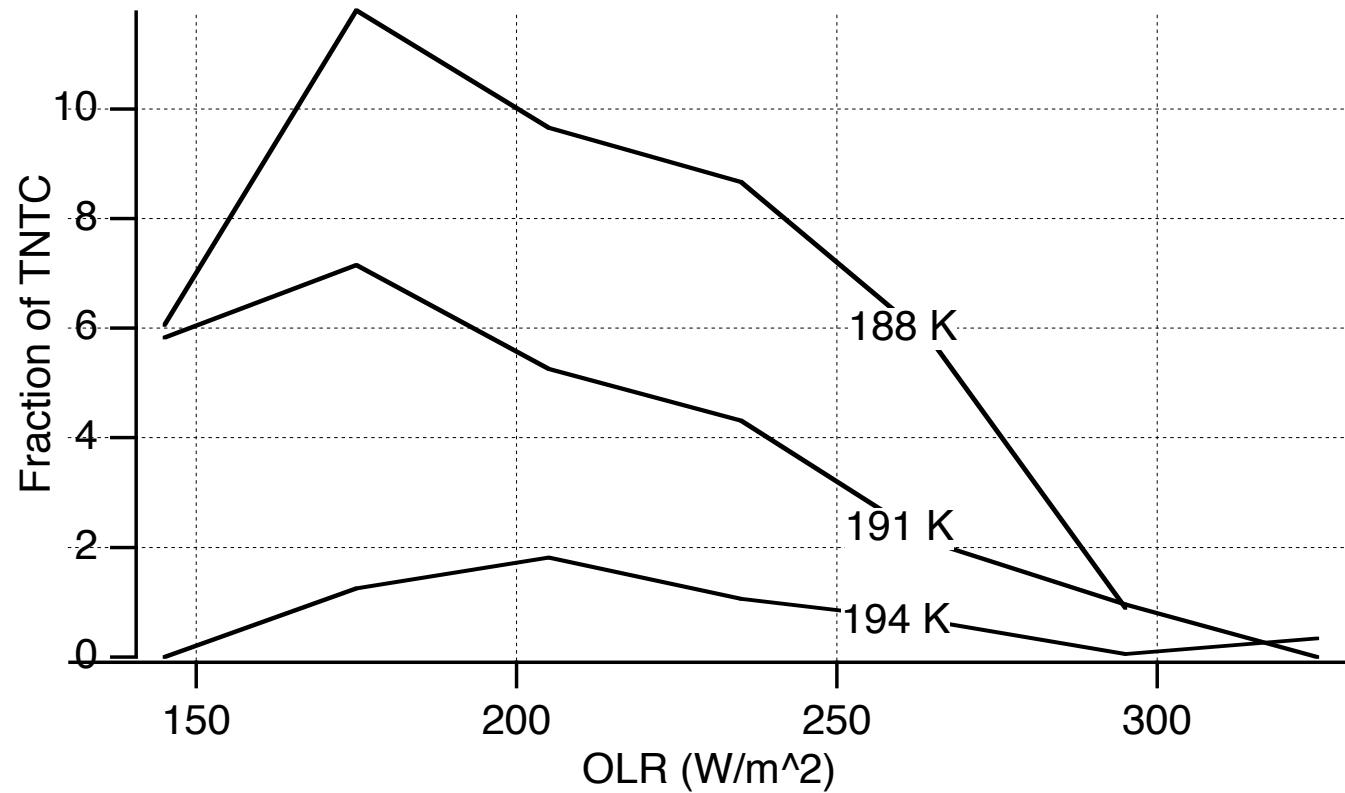
JFM



OLR

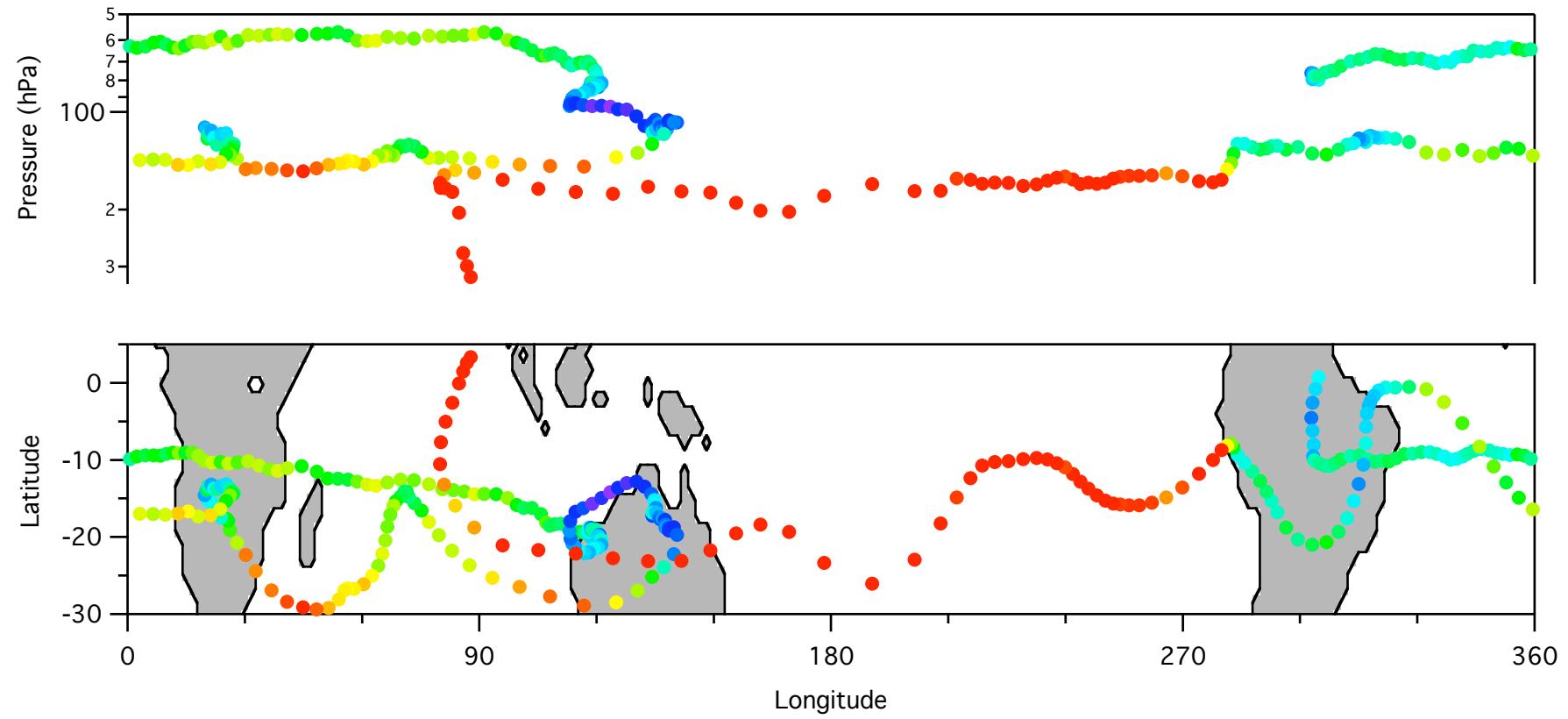
dehydration
hydration

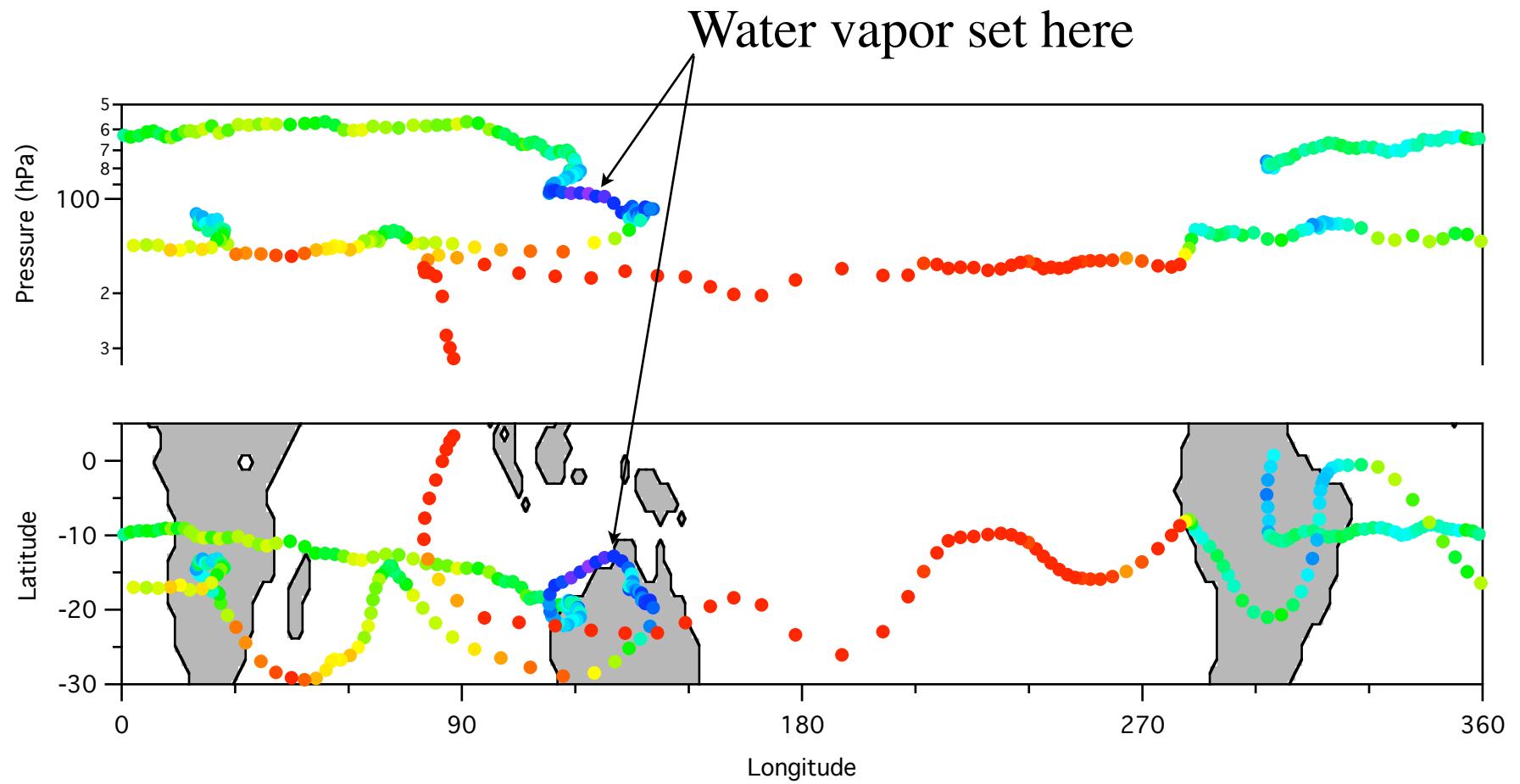
Dessler et al. (2006), Tropopause-level thin cirrus coverage revealed by ICESat/Geoscience Laser Altimeter System, *J. Geophys. Res.*, DOI: 10.1029/2005JD006586.

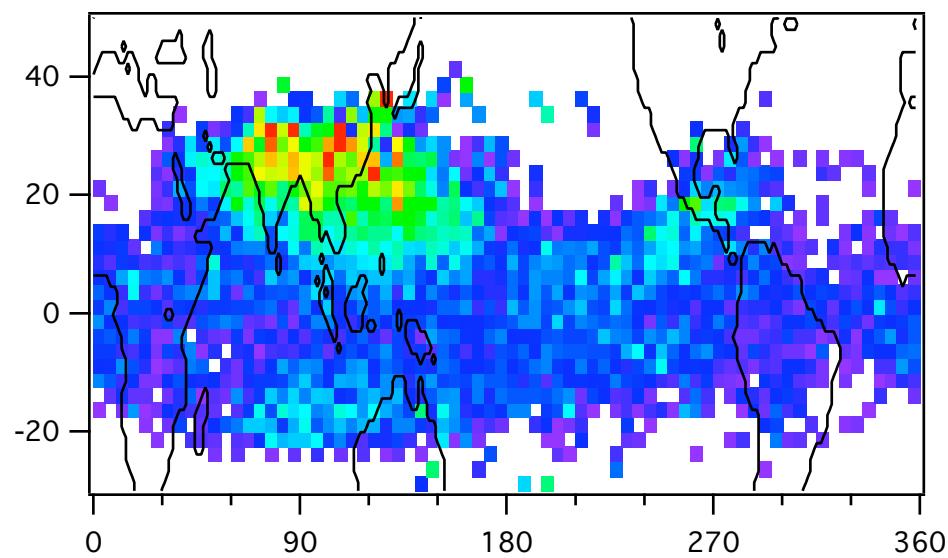


Fueglistaler et al. (2005), Stratospheric water vapor predicted from the Lagrangian temperature history of air entering the stratosphere in the tropics, J. Geophys. Res., 110, D08107, DOI: 10.1029/2004JD005516.

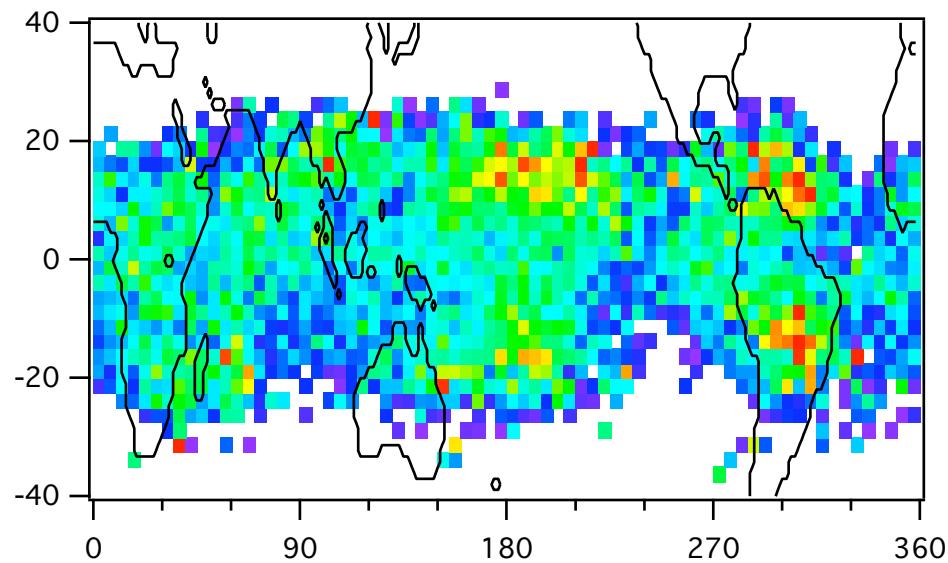
- Trajectories are initialized every 2° in longitude and latitude (from 30°N - 30°S) at 400-K potential temperature
- ERA-40 four-dimensional winds are then used to follow these parcels backward in time 90 days
- Trajectories that can be traced back to the 340-K level (~ 11 km) constitute an ensemble of trajectories that are used to evaluate the characteristics of tropical troposphere-to-stratosphere transport
- trajectories cover 1993-1999



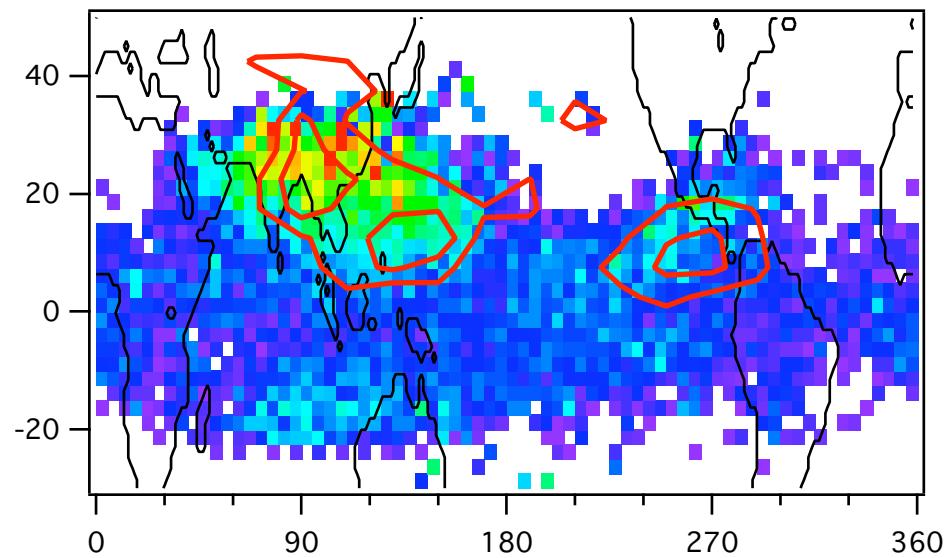




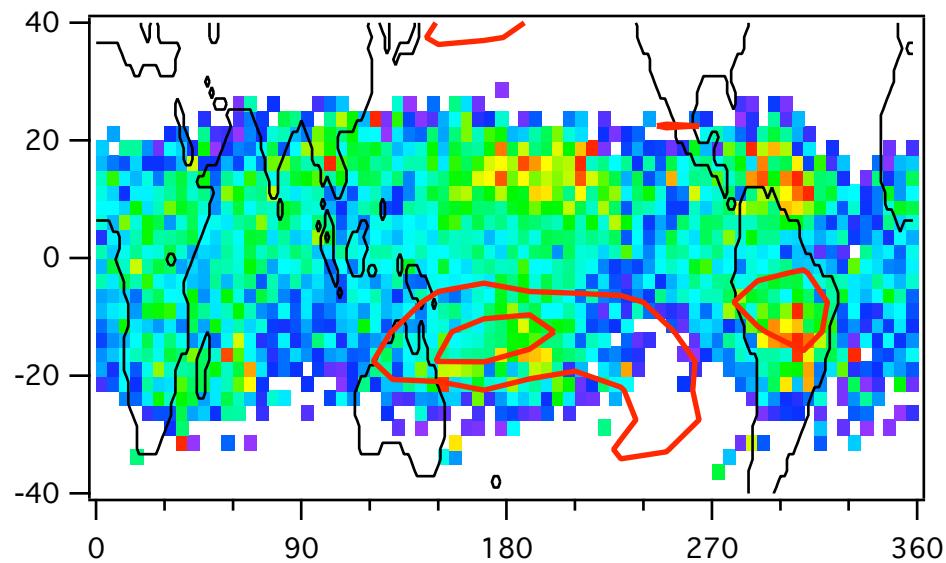
JJA



JFM



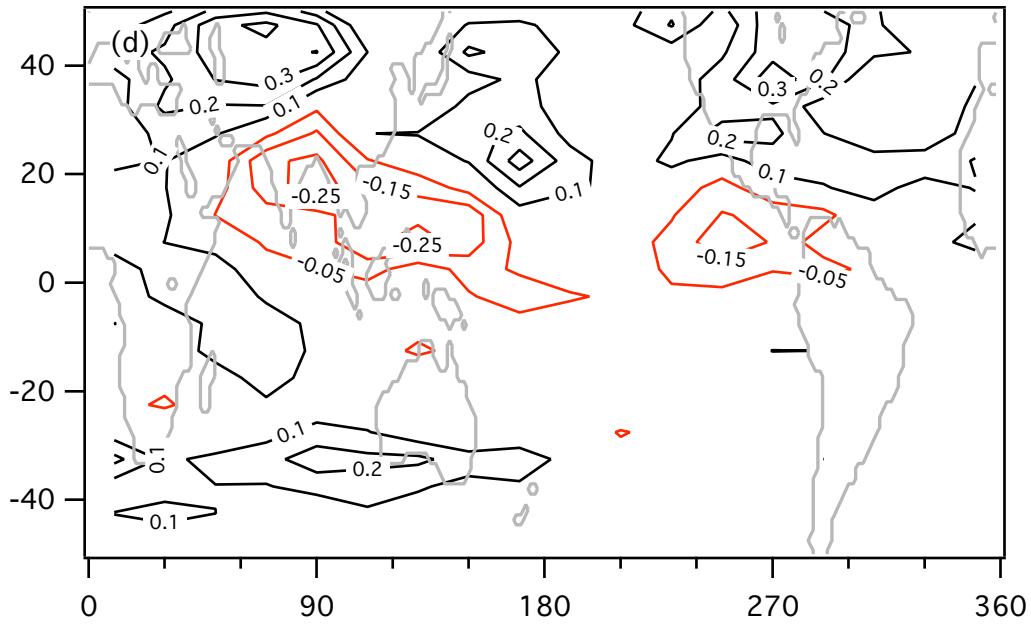
JJA



JFM

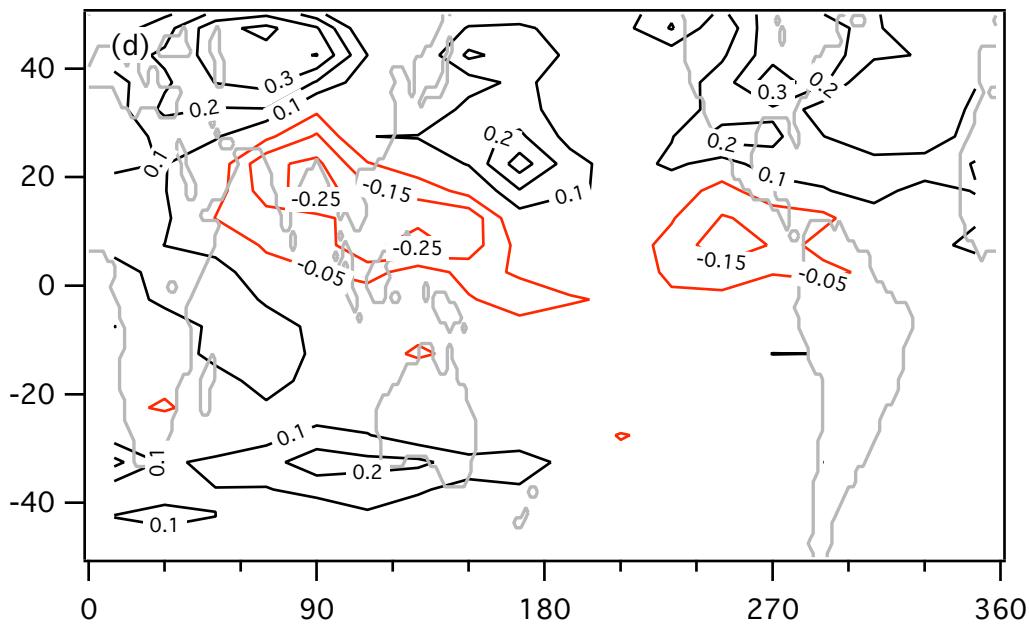
Conclusions

- Maps of dehydration & hydration have been calculated
- Regions of dehydration correlate with regions of high RH
- Regions of strong hydration occur in mid-latitudes in JJA, likely due to convection
- Ambiguity due to trajectory method
- Is dehydration reversible or not?
- General agreement with trajectory analyses



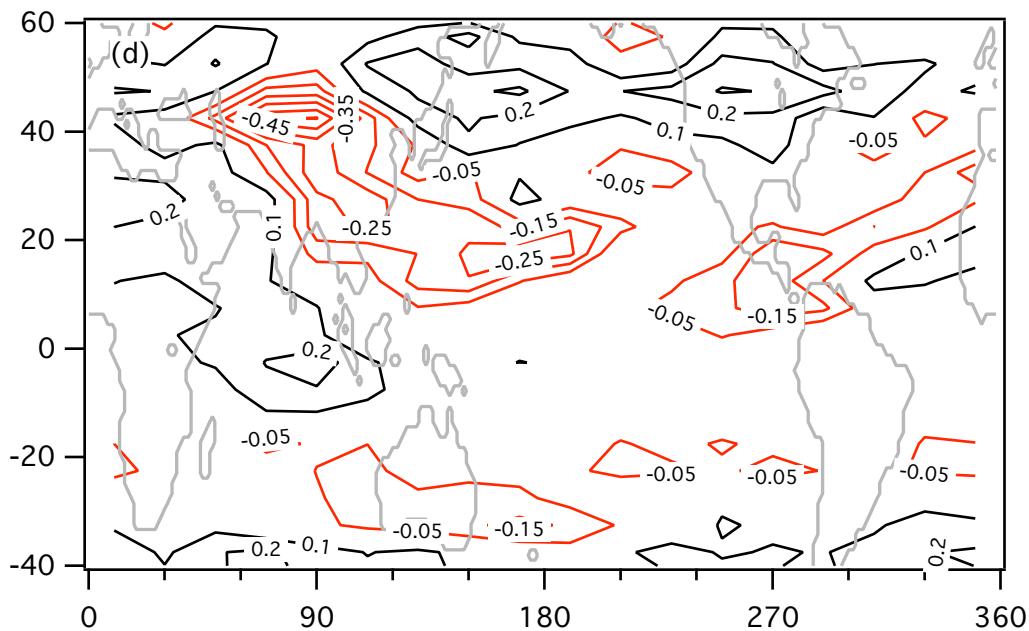
JJA

dehydration
hydration



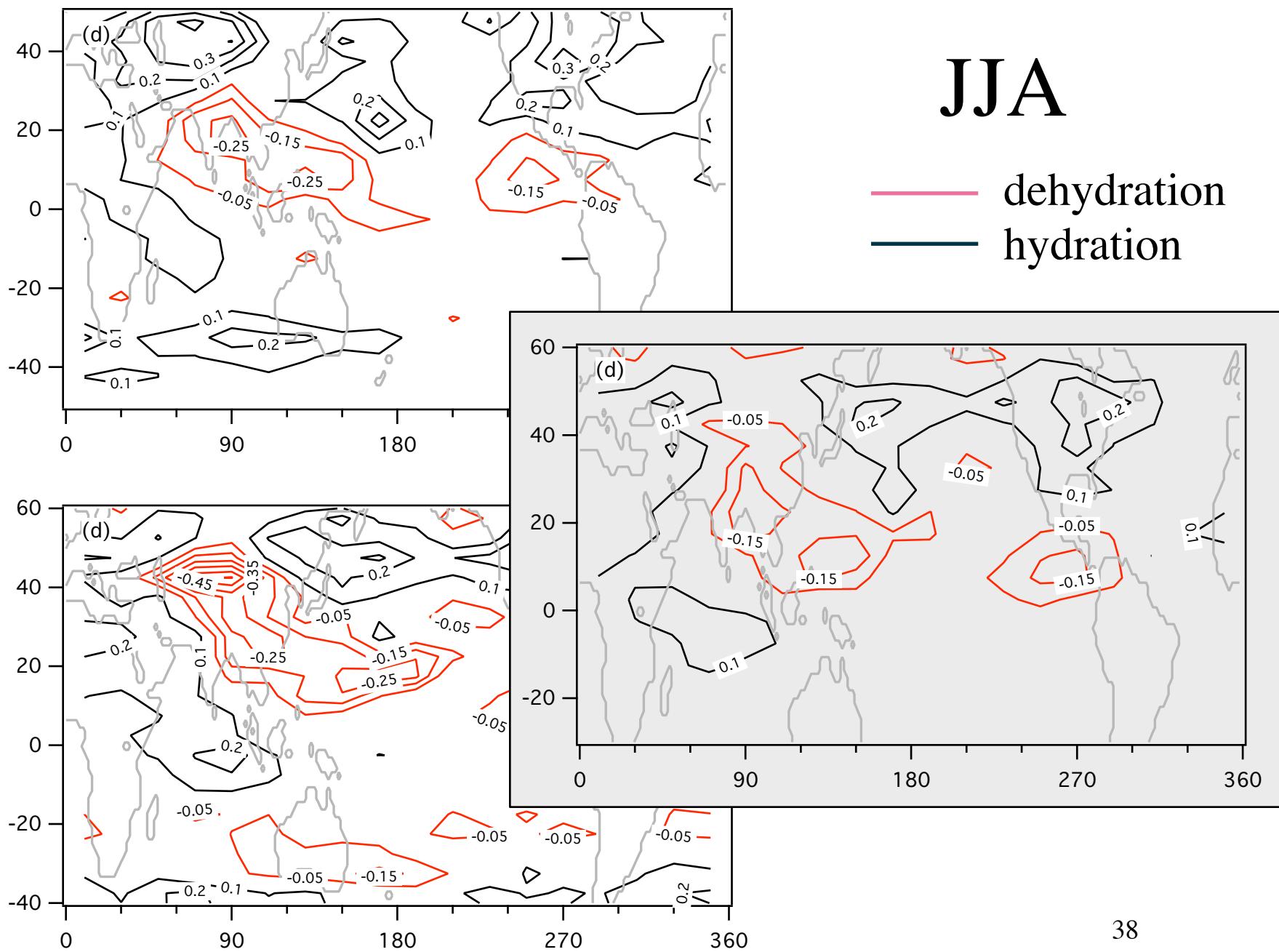
JJA

dehydration
 hydration

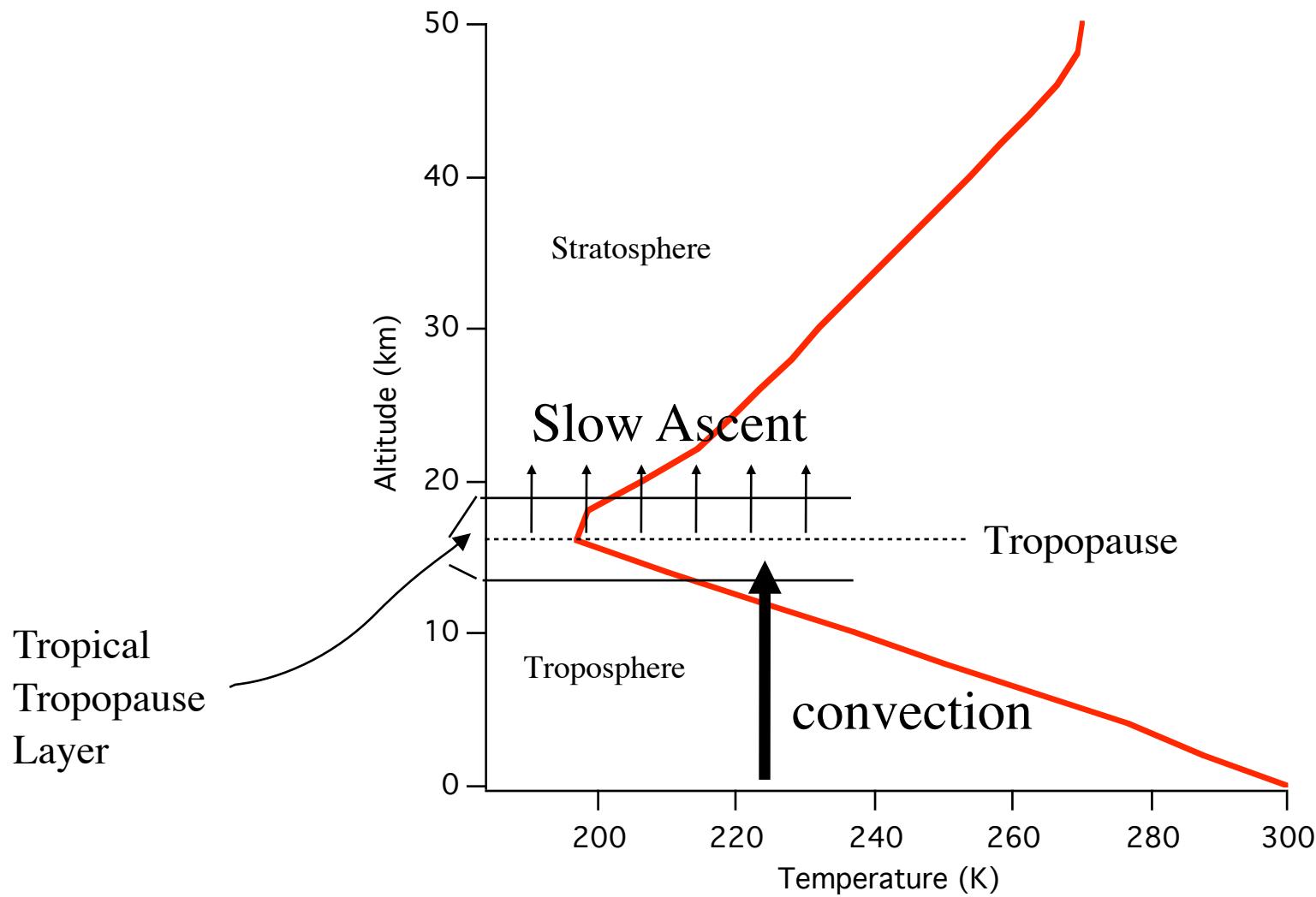


JJA

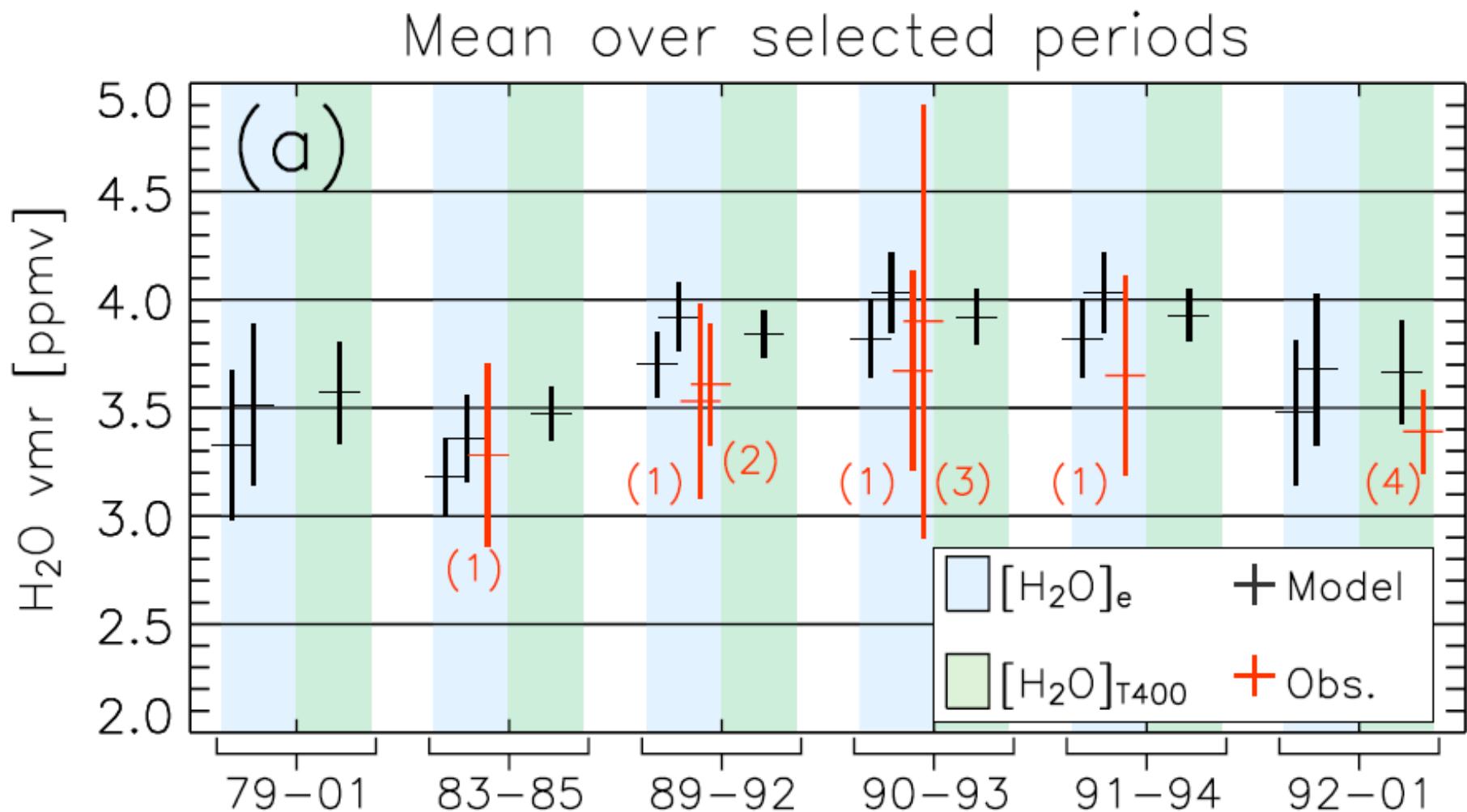
dehydration
hydration



Atmospheric Structure



F05 model



F05 conclusions

- The model does a pretty good job of simulating LS H₂O
- H₂O can be simulated by large-scale (resolved by ERA-40) processes
- They concluded that small-scale processes, like convection, need not be invoked to explain LS H₂O

But there is a problem with F05 ...

Isotopes

HDO background

- Condensation preferentially removes HDO
- Thus, as a parcel cools and H_2O condenses and sediments, the HDO / H_2O of the remaining vapor decreases
- Rayleigh curve: condensation occurs at 100% RH and in equilibrium with the vapor, and that the condensate formed is instantaneously removed
- HDO provides additional information about the dehydration history of TTL air